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emiconductors—
a new influence in design

page 319

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Engineering Materials and Design

★ *The Magazine for Engineering Designers*

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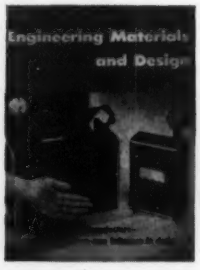

Existing and new sound level meters —an example of how the use of transistors enables the size of equipment to be reduced. The Dawe 1400E model on the right is still in prototype stage.

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The Significance of Sintering by SMC

Organisations of all sizes in many different trades are increasing their profits by having their small metal components made by SMC. In many cases a saving of 40% or more is being effected by using sintered components because *they can be made to a dimensional tolerance of half-a-thousandth of an inch* without machining! In addition they eliminate the capital outlay required on new lathes, auto-capstans, etc. This all adds up to fabulous economies, particularly where large quantities are required.

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MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Trends in Compressor Design

SOME MARKED CHANGES in the type of compressor currently being bought by industry are reported by Consolidated Pneumatic Tool Co. Ltd. One interesting trend is the rise in popularity of the rotary type of compressor, especially for portable operation.

Until 1954, portable compressors were commonly of the reciprocating type, using a cylinder and piston for the positive compression of air, with cooling either by a forced air draught or by water circulated in jackets round the cylinders. In 1954, the first range of oil-flooded rotary power vane compressors as a series of models with capacities of up to 600 cu. ft. per min. at 100 p.s.i. pressure was introduced to the U.K. market. A particular point of this type of compressor is that the oil provides a ready medium for the removal of the heat of compression. Thus as the air is cooled at the time of compression, two-staging is unnecessary for adiabatic reasons and no intercoolers are provided.

In 1956 the portable compressor market expanded by 19 per cent, although sales of reciprocating compressors rose by less than 1 per cent, almost the entire expansion in the market being accounted for by sales of rotaries. In the following year the portable market expanded by only 5 per cent and during this year reciprocating compressors lost ground to the extent of 7 per cent, whilst rotaries gained by over 40 per cent.

Until the end of last year, the portable rotary was entirely of the vane type and in the five years since its introduction it has succeeded in securing a half share of the total portable market. A new-comer to this field, however, is the portable screw compressor and it remains to be seen how much of a challenge this type of compressor will present to the market. As yet, little operating experience is available and the two manufacturers in this field appear to hold divergent views on whether compression in two stages is necessary.

Interest in Electric Vehicles

REPORTS FROM THE U.S. in recent months have disclosed a revival of interest in electrically-driven motor cars and delivery vans. This month is scheduled for the production of the Charles Town-About by Stinson Aircraft Tool & Engineering Corp., who have designed an attractive-looking car weighing 1,875 lb. and powered by two 2½-h.p. motors. Speeds up to 60 m.p.h. and a range of 80 miles are claimed. Originally it was to be powered by a selenium battery, but no details have been released on its characteristics. It is understood that prototypes have been powered by standard lead-acid cells.

The American Motors Corp. and Sonotone Corp. have recently announced a long-range project to explore the possibilities of what they call a "revolutionary electric automobile". This car is to be based on a sintered plate nickel-cadmium battery, but will have a built-in recharger driven by a small high-performance engine.

An ambitious approach is revealed by the De Soto division of the Chrysler Corporation who are designing a vehicle to be powered by a fuel cell with drive to individual wheels. To make the best use of the output from the fuel cell, lightweight reserve batteries of high specific output are to be incorporated. Regenerative braking of the motors will also enable the energy available under braking conditions to be used to augment the output from the fuel cell.

In this country an interesting development is being carried out by Traction Electric Ltd., who are designing an electric motor car to be powered by a new lightweight lead-acid battery. An important feature of this battery is that it may be given a half charge in half an hour without overheating, so that refresher charges may be used to extend the range of the vehicle. The main feature of the vehicle design will be lightweight (glass fibre body and plastics bumpers) coupled with passenger safety (absence of sharp internal projections with foam padding). Prototypes are already running for performance and battery tests.

Hydraulic Extrusion

A METHOD of extruding aluminium components hydraulically and without the use of plungers is reported to have been developed experimentally in the U.S.S.R.

In a demonstration of the technique, a compressor provided a gradual build-up of hydraulic pressure in the working fluid (in this case oil) surrounding the billet. At a certain pressure (4,500 atmospheres) the billet was ejected through the die with a loud discharge, but no details are known of how billet flow is restrained until the required pressure is attained.

The billet metal was forced through the die at speeds up to tens and even hundreds of yards per second. Friction in the billet-die contact zone dropped sharply after billet deformation began, due to the formation of a thin fluid film (called a hydrodynamic wedge) between the die and billet metal. This decrease of friction lowers the forces necessary for initiating extrusion and ensures uniform deformation of the billet. Preheating the billet and container also reduces the initial resistance to deformation. It is concluded that extrusion is possible with relatively low pressures (several hundred atmospheres), the initiation of deformation being helped by a shock wave generated within the container by a powerful electrical discharge.

Powder Dispenser for C.I. Production

THE VALUE of introducing powdered slag-making materials into a metal has long been recognised. New equipment recently developed by a British company is based on dispensers already widely used for the injection of metal powders for gas cutting, and this system introduces fluxes into the body of a melt to permit reactions to take place more rapidly and efficiently.

Desulphurisation of iron with calcium carbide and recarburisation with powdered graphite are two processes which are technically and economically successful, and both these materials are injected into the metal by means of a stream of nitrogen through a graphite or refractory lance.

The treatment may be carried out in ladles following melting and also directly in high-frequency induction furnaces. There is considerable scope for this process in the manufacture of high carbon iron and of steel. In the former case the prospect of recarburising from high proportions of steel or cast-iron scrap is favourable because of the difference in cost between pig iron and scrap. For steelmaking powder dispensation in the form of lime, with oxygen as a carrier gas, is likely to offer many advantages.

PICTURE NEWS

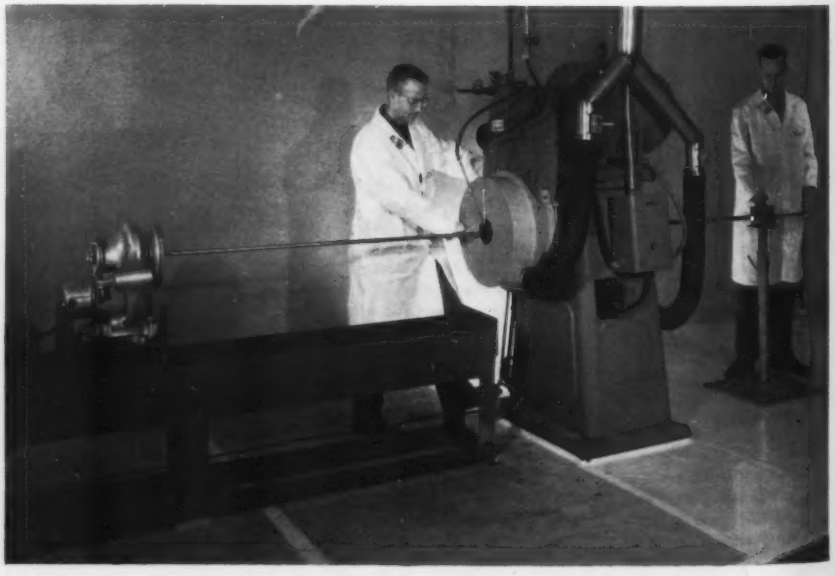
IN THE WORLD OF MATERIALS & DESIGN

POROUS NYLON FOR BEARING

Oil mass shifts are said to be drastically reduced with a sintered nylon bearing retainer that is impregnated under vacuum with an instrument oil. Oil is distributed evenly throughout the retainer structure and sufficient lubricant is held for the bearings to operate at high speeds for long periods. The nylon absorbs about twenty per cent of its own weight of oil. This type of bearing is developed in the U.S.A. by the Barden Corp. for inertial guidance systems.

SIXTEEN-STAGE IMPULSE GENERATOR

This 3,200,000-volt impulse generator is a feature of the laboratory at the new Erith works of B.I.C.C. Ltd. Designed for development testing of high-voltage cables, the generator is of two-column construction, having sixteen stages of 0·28 microfarad per stage. It is provided with automatic tripping, ultra-violet ray gap stabilisation, remote polarity changeover switchgear and a capacity potential divider. Picture here shows a technician setting the gap on one of the stages.



ONE-STEP CERAMIC CLADDING

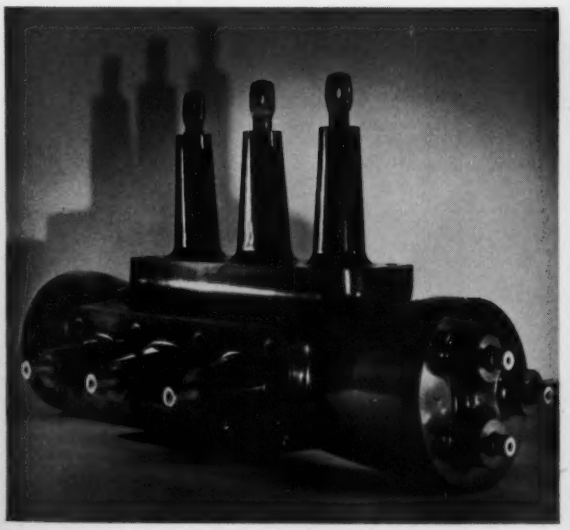
An interesting development in the U.S.A. is the swaging of ceramics to shape and cladding with metal in a single operation. This was referred to at the recent Metals Congress at Cleveland, Ohio, in connection with the fabrication of ceramic fuel elements. The Farmer-Norton equipment shown in this picture is a rotary swager of standard design that is currently being used by General Electric Co. for this one-step ceramic cladding process.

ERGONOMICALLY DESIGNED ▲

This WM 16 general-purpose oscilloscope is the kind of satisfactory result discussed at the recent conference of the Ergonomics Research Society. It was produced by E.M.I. Ltd., one of the few industrial organisations in the U.K. yet employing a trained staff ergonomist, and is part of a new range of oscilloscopes designed by the company in this way.

LARGE GLASS-FIBRE MOULDINGS ▼

Five glass-fibre reinforced plastics mouldings used on this accounting machine are believed by the producers, Universal Metal Products Ltd., to be the largest mouldings currently being produced by the preform/matched metal moulding technique. The covers, side panels and drip tray form the cabinet of the machine, and are treated after moulding by spray-painting in a crackle finish prior to assembly.



EPOXY RESIN BUSBAR UNIT ▲

One of the features of the Ciba (A.R.L.) Ltd. stand at the International Plastics Exhibition in London this month is this 11-kV. three-phase busbar unit with dividing box attachment for J-type switchgear. The unit is completely cast in coloured epoxy resin.

LAMINATED WOOD IMPELLERS

This 8-ft. industrial fan unit is equipped with wooden blades laminated with Aerodux 185 resorcinol-formaldehyde adhesive. The Airscrew Co. & Jicwood Ltd., who are large-scale producers of industrial fan and impeller blades, use for this purpose white seraya wood which has a density of about 28 lb./cu. ft.

Smelting Iron with Natural Gas

ALTHOUGH deposits of high-grade iron ore are widely distributed in the world, it has in the past been only where abundant supplies of coking coals exist also that blast furnaces have been built and steel produced.

A recent development, which may bring about the production of steel in areas where no coking coal is to be found, relies on natural gas. The Hy L process, as it is called, was developed by Hojalata y Lamina, S.A., one of Mexico's principal steel producers, with engineering assistance from the M. W. Kellogg Co. of New York. This new process yields a sponge iron which may be substituted for pig iron or scrap in making steel.

In the 200-tons-a-day plant at Monterrey, Mexico, which formed the subject of a film shown recently in London, five reactors are used; the reaction cycle for each is four hours and an additional thirty minutes are required for dumping and charging. The natural gas, which is first desulphurised, passes through a Kellogg high-pressure steam-reforming furnace. When admitted to the reactor, the reducing gas contains 85 per cent hydrogen and carbon monoxide, the remainder being carbon dioxide, methane and water vapour. Ore ranging in size from ¼-1¼ in. is charged to the reactors, each of which holds 30,000 lb. About 21,000 cu. ft. of natural gas is required per ton of reduced ore, the final reduction taking place within a temperature range of 850-1,000 deg. C. The hot sponge iron is discharged from the reactor to a hopper for transportation to a melting furnace. Although, as for the Mexican plant, natural gas provides the greatest economic advantage, the process is said to be possible with gases produced from fuel oil or coke oven gases.

New Plastics in Germany

THE POLYCARBONATES, which made their first appearance on the market a short while ago, are a group of polyesters with thermoplastic properties and are chiefly notable for the wide temperature range over which they can be used: they are said to be heat-resistant up to +135 deg. C. and cold-resistant down to −100 deg. C.; in other words their practical application covers a temperature range of almost 240 deg. C. They combine outstanding mechanical properties with very good electrical characteristics; both their dielectric constant and their phase angle remain unchanged in the practical field of application, i.e., up to 135 deg. C. Added to this is the fact that it has been possible to produce the polycarbonates as transparent material. Because of their good resistance to acids, this makes them suitable for the production of transparent, impact-resistant accumulators. In addition, coverings for electrical requirements to resist temperatures above 100 deg. C. can also be made from polycarbonates.

The international trade fair, Plastics 1959, to be held in Düsseldorf this autumn, will provide the first opportunity of seeing these latest developments by the German plastics industry on display. Among the objects exhibited will be fluorescent lamp holders, inspection glasses, windows for machines and apparatus and direction-indicator lamps and side and tail lamps for motor vehicles. Long duration tests with street lamps in temperate climates and in tropical latitudes are said to have proved very successful.

A group of new p.v.c. polyblends is also of interest, a range of plastics consisting of mixtures of p.v.c. and chlorinated polyethylenes produced as hard, impact-resistant and as soft, flexible types. In this plastics it has been possible to achieve the good dielectric properties of hard p.v.c. with materials which are flexible without having plasticisers added to them. By using these plastics for wire insulation it has been possible to obtain a hitherto unequalled standard of insulation resistance. An added feature of these new p.v.c. types is that they can be used at temperatures down to −40 deg. C. and up to +85 deg. C., which means that they have a much greater temperature range in application than the plasticised p.v.c. materials so far used.

IN NEXT MONTH'S ISSUE

Principal features in the July issue of

ENGINEERING MATERIALS AND DESIGN will include:

Recent Developments in Air Suspension
Its advantages in current practice.

Selection of Materials for Castings
Applications of castings, their scope and limitations.

Stepless Transmission with Constant Mesh
New development from the U.S.S.R.

Design Problems with Boron Fuels
Their properties and special requirements.

Electrical Insulation

PAPERS presented at the recent conference on electrical insulation held by the U.S. National Research Council have an important bearing on development of high-temperature insulation systems and corona-resistant material.

Discussion on 200-300 deg. C. systems revealed a new family of organic polymers under development by the Du Pont company, showing considerable potential for application in the same temperature range as silicones and p.t.f.e. In addition to outstanding thermal and oxidation stability, exceptionally good mechanical properties and solvent resistance are also shown. The work so far has been concentrated on a high-temperature fibre, but the polymer can also be fabricated into films, varnishes and wire enamels.

Another indicated that layer and slot insulations made up of combinations of mica, mica paper, glass cloth and inorganic binders of the aluminium acid phosphate type have been used satisfactorily in motors and transformers at temperatures as high as 600 deg. C.

In an effort to produce a satisfactory potting and embedding compound, the General Electric Co. in the U.S.A. has developed a high-temperature transformer in which the coils are potted with inorganic cement within a hermetically-sealed metal can. Much work is in progress to develop materials with sufficient moisture resistance to eliminate the can.

Aluminium Submarine

A 48-FT.-LONG underwater vessel called the *Aluminaut* is being built by the Reynolds Metal Co. for exploration of the ocean bottom at great depths. This could well be the forerunner of a new series of deep-diving vessels with many possibilities for research as well as for naval strategy in reconnaissance, attack or defence. The pressure hull of the *Aluminaut* is to be made of 6-in.-thick aluminium plate which has been chosen because of its great strength in relation to its weight, contributing a buoyancy not possible with other metals. Since the hull will be less compressible than water, the boat will descend when it carries excess weight, but it will not fall all the way to the bottom unless additional water ballast is added. Therefore, a controlled descent can be arranged so that the boat will remain suspended at a selected depth where the weight and buoyancy are in equilibrium.

FOR MORE INFORMATION:

Consolidated Pneumatic Tool Co. Ltd., 232 Dawes Road, London, S.W.6.
Stinson Aircraft Tool & Engineering Corp., 7961 Clairemont Mesa Boulevard, San Diego, Cal., U.S.A.
American Motors Corp., 14250 Plymouth Road, Detroit, 32, Mich., U.S.A.
Chrysler Corp., 341 Massachusetts Avenue, Detroit, 31, Mich., U.S.A.
Traction Electric Ltd., Stone Street, Stelling, nr. Canterbury, Kent.
Kellogg International Corp., Kellogg House, Chandos Street, London, W.1.
International "Plastics 1959" Exhibition, Ehrenhof 4, Düsseldorf, Germany.
E. I. du Pont de Nemours & Co., Wilmington, 98, Del., U.S.A.
General Electric Co., 1 River Road, Schenectady, 5, N.Y., U.S.A.
Reynolds Metal Co., Richmond, 18, Virginia, U.S.A.

Engineering Materials and Design

THE IMPACT OF SEMICONDUCTORS

TRANSISTORS today stand on the threshold of maturity. Over ten years have passed since the transistor was first announced by the Bell Telephone Laboratories, but it is not too early to give serious consideration to the influence which this development will have, and indeed is already having, on engineering and product design. The transistor itself, its design, manufacture and testing are primarily the province of the physicist and chemist, and engineers are becoming increasingly involved in the design and construction of equipment for the manufacture of transistors. But of still greater importance are the possibilities which arise from the use of transistors in the development of new engineering products and the redesign of old ones. Some of the immediate effects of transistors are discussed in further detail on page 319 of this issue, but ultimately it is certain that the effects of semiconductor research will be felt in nearly all branches of engineering.

The transistor started as a substitute for the thermionic valve, having advantages of smaller size, lower power requirements and greater reliability. Already, however, the transistor and other semiconductors are developing along novel lines in making practicable the control, transmission and processing of information. Of special interest to engineers is the use of semiconductors for thermo-electric conversion of heat and light into electrical energy. Conversion efficiencies of over ten times that of conventional bi-metals have been claimed. The Peltier effect, discovered in 1834, by which heating or cooling of junctions occurs depending on the direction of current flow, has been transformed by the advent of semiconductors, from a scientific curiosity to a property of important engineering significance, as it opens up interesting possibilities for the design of refrigerators and for the selective cooling equipment.

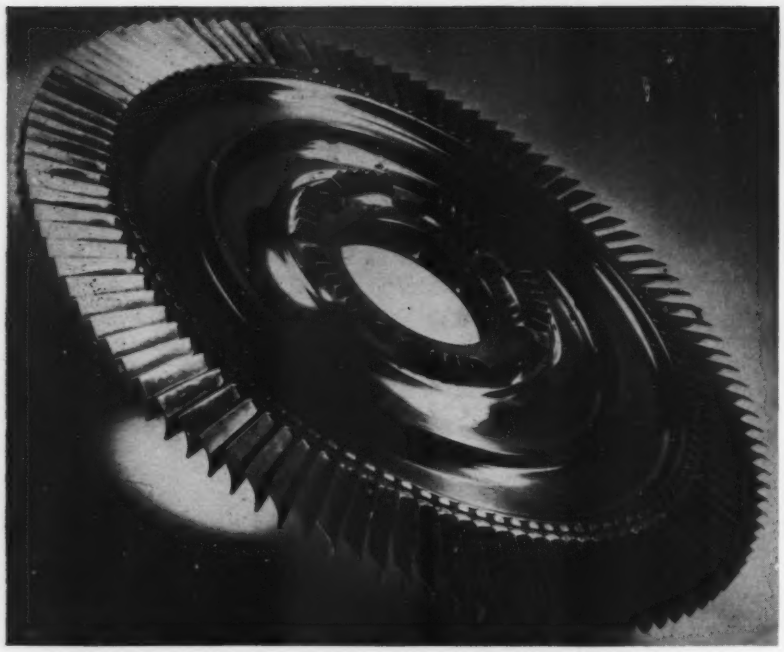
In the manufacture of semiconductors it is essential to have a complete understanding and control over the minute impurities which must be present in otherwise perfect crystals. This control has resulted in the development of new techniques and automatic machinery which are also finding uses in other branches of materials technology. For instance, zone refining, which was developed especially for semiconductors, is now being applied to the purification of other materials.

Germanium and silicon are the two best-known materials for transistor manufacture, but these are only two of literally hundreds of potentially useful semiconductors. Such materials as indium phosphide and gallium arsenide are being developed for operation at temperatures up to 400 deg. C. and many other compounds are already showing promise for high-temperature power rectifiers and temperature and light sensing elements.

One of the most important aspects of semiconductor development has been its tremendous influence in triggering off renewed activity in miniaturisation. Although considerable strides were made for airborne equipment during and just after World War II, transistors have caused a further spate of development in the production of almost unbelievably small electronic components. This was overwhelmingly obvious at the 1959 R.E.C.M.F. Exhibition at which a large variety of very small components was shown and most of these exhibits were designed for use with transistors. In some cases semiconductors have even replaced these components, such as variable capacitors now available for special purposes in the form of a semiconductor device. Transistors have also given rise to increased development of printed circuits and this is already having far-reaching results in the design of electrical instruments and light current control gear. Even without further research the present reservoir of knowledge appears to be sufficient to ensure a major expansion of transistor electronics, much of which will appear in association with engineering products. There is, however, no sign of saturation in research expenditure on semiconductors, so that progress continues to increase.

In 1957 the electronics industry in the U.S.A., considerably helped by transistor development, was already ahead of the electrical power industry in dollar output, and progress in Britain has been along comparable lines. In the U.S.A., where the transistor was first developed, production and technical development appear to be ahead of the British efforts. Many other countries, notably Russia and Japan, have made great strides in certain aspects of transistor production and application. This situation is not yet serious for the U.K., but if we are to hold our overseas markets British industry will have to adopt a keener and more lively attitude than it did in the immediate post-war years in accepting the expansion of electronics.

Electronics is rapidly becoming a key industry and its techniques are essential for the maintenance and increase in productivity. It does not require a knowledge of quantum mechanics to see the practical importance and immense possibilities of semiconductors. Engineers must therefore try to understand the implications and be prepared to meet the demand for revolutionary new designs which are now being made possible. The International Convention on Transistors and Associated Semiconductor Devices, organised by the Institution of Electrical Engineers and the associated international exhibition, the first of its kind in this country, mark an important step in the history of semiconductors and will undoubtedly focus the attention of many engineers on a subject which will have an increasing effect on engineering product design during the next ten years.



Armstrong-Siddeley high-temperature turbine wheel comprising a Nimonic 90 forged disc bladed with Nimonic 100 forged blades.

SPECIAL USES FOR NIMONIC ALLOYS

Although demands of jet engine performance originally created a need for the Nimonic alloys, their application is now extending far into other industries. Their properties and typical uses are discussed here

by G. WALLER*

NICKEL-CHROMIUM alloys have been used in heat-resisting applications for more than fifty years because of their excellent resistance to oxidation. During the past two decades, considerable development of the simple nickel-chromium system has taken place and a number of more complex alloys have been evolved which retain this valuable characteristic while providing high mechanical strength in the upper ranges of temperature. Even when operating at bright-red heat, they remain stiff and capable of supporting useful loads without excessive distortion.

Prominent among these new nickel-chromium materials are the Nimonic alloys, a family of wrought alloys developed in the laboratories of The Mond Nickel Co. Ltd. and made by the associated concern, Henry Wiggin & Co. Ltd. It was the Whittle jet-engine programme which brought this group of alloys into being. When existing materials proved inadequate for the turbine blades and other high-temperature parts of the jet engine, a research programme was launched to find alloys which would remain strong at temperatures not much below their melting point. A promising starting point was the well-known 80/20 nickel-chromium composition used for electrical resistance heating elements. With this as a basis, the Mond laboratories produced more than a thousand experimental alloys during 1940, of which two showed interesting possibilities. These eventually became Nimonic 75 and 80 respectively, and were the first of a series which has played a vital part in gas-turbine development and is now proving of considerable importance to industry in general (see Table 1).

* *Henry Wiggin & Co. Ltd.*

Creep-tested Alloys

The chief division within the Nimonic series is between those alloys which are creep-tested before use and those which are not. This calls for a word of explanation to engineers who are unfamiliar with gas-turbine blade problems. "Creep" is the progressive deformation which takes place when metals are stressed at high temperatures; it occurs at stresses below the limit of proportionality as determined in a short-time tensile test and is therefore of the utmost importance in certain classes of high-temperature engineering. An excellent example is in turbine rotor blading, where the combination of centrifugal, bending and flutter stresses will gradually deform the blades and eventually cause their failure either by rupture or by mechanical damage due to the closing of running clearances. To provide the turbine designer with the necessary

information on creep behaviour, an extensive programme of laboratory testing of Nimonic alloys has been in hand for more than fifteen years. Moreover, every melt of the creep-resisting alloys in the series has to be tested against specified creep criteria before release to customers. Fig. 1 shows the improvement in creep properties achieved with successive Nimonic alloys using the 100-hour stress/rupture case as a criterion.

The strength of those in the creep-resisting group is brought about chiefly by precipitation-hardening. They therefore require heat treatment in two stages—a solution treatment, followed by age-hardening. Differing mechanical properties can be achieved by using various heat treatments, but for all normal purposes the maker's standard procedure is the simplest and most effective. An example is the heat treatment for Nimonic 90; this comprises solution treatment of eight hours at 1,080 deg. C., air cool, and ageing for sixteen hours at 700 deg. C., air cool. One of the creep criteria for this alloy when heat-treated in this way is a minimum life to rupture of seventy-five hours at 750 deg. C. when stressed at 19 t.s.i.

In many applications good creep-resistance is of less importance than the other high-temperature properties offered by the Nimonic alloys. These include high stress to rupture, excellent resistance to oxidation, good fatigue strength and the ability to withstand violent thermal shock. Because of their adherent oxide coatings, the alloys stand up well to various types of corrosive media, e.g., attack by vanadium pentoxide in plant operating on residual fuel oils. One of the most important physical properties of a heat-resisting alloy is structural stability; in this context, it is interesting to note that the high nickel content of the Nimonic alloys renders them free from sigma formation and they do not undergo the phase changes in service which can adversely affect the strength and corrosion resistance of certain stainless steels.

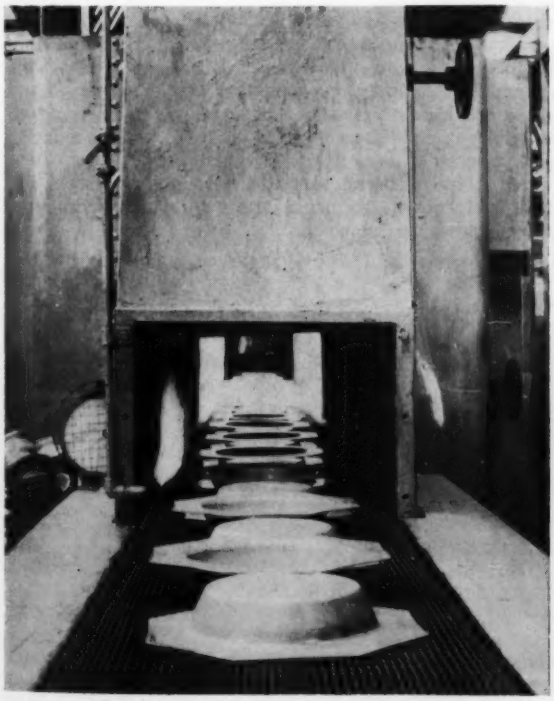
It must be realised that the Nimonics are of the class known as "super-alloys" in the U.S.A. and are extremely tough and obdurate by conventional standards. It is obvious that materials which are required to operate in service at temperatures only 200 deg. C. or so below their hot-working temperature are not easy to forge, roll or extrude. There are problems also in cold-working and machining, but the necessary techniques are well-known and an extensive background of production experience has been built up since these alloys were first introduced.

There are at present five creep-tested Nimonic alloys. The oldest in origin is Nimonic 80A, which is essentially an 80/20 nickel-chromium alloy strengthened by small additions of aluminium and titanium. Further developments of this composition led to about 20 per cent of the nickel being replaced by cobalt, the resulting alloy being named Nimonic 90. With improvements in hot-working techniques, it became possible to increase the level of titanium and aluminium contents to raise the high-

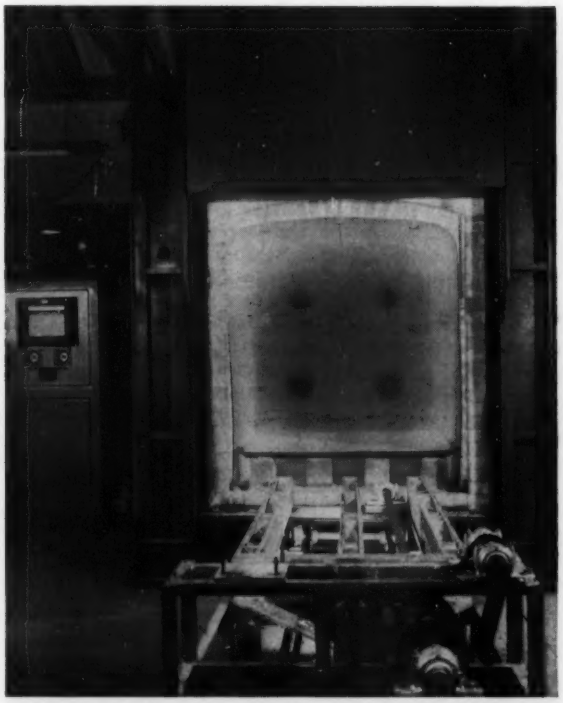
TABLE 1. Main Nimonic alloys and their broad applications

CREEP-TESTED	
Nimonic 80A Nimonic 90 Nimonic 95 Nimonic 100 Nimonic 105	For use at elevated temperatures where stresses are high and creep-resistance is of primary importance
NON-CREEP-TESTED	
Nimonic 75 Nimonic DS	For use at elevated temperatures where stresses are moderate. Much used for fabricated parts.
Nimonic 80A Nimonic 90	For use where high-temperature strength is required but creep-testing is not necessary.

Nimonic 95, 100 and 105 are intended chiefly for creep-resisting duties and are not normally released without creep-testing.



Heat-treating pressings at a factory of Joseph Lucas Ltd. The furnace belt is of woven Nimonic DS wire.



Four fans and internal air guide in this Hedin heat-treatment furnace (to operate on forced air draught at 1,100 deg. C.) are fabricated from Nimonic 75 sheet.

TABLE 2. Physical properties of the Nimonic alloys

	Nimonic DS	Nimonic 75	Nimonic 80A	Nimonic 90	Nimonic 95	Nimonic 100	Nimonic 105
Specific Gravity	7·97	8·35	8·2–8·25	8·27	8·11	8·04	8·00
Melting Range, °C.	1,320–1,350	1,390–1,420	1,360–1,390	1,360–1,390	1,340–1,375	1,310–1,380	—
Specific Heat, c.g.s. units							
20–100°C.	—	0·11	0·103	—	—	—	—
20–900°C.	—	—	0·128	—	—	—	—
Thermal Conductivity, c.g.s. units							
at 100°C.	0·034	0·032	0·029	0·030	—	—	—
at 900°C.	0·075	0·071	0·066	0·069	—	—	—
Mean Coefficient of Thermal Expansion millionths per °C.							
20–100°C.	14·2	12·2	11·9	11·6	12·8	12·4	11·9
20–900°C.	19·3	16·0	15·8	17·0	17·0	16·8	—
20–1,000°C.	—	—	—	—	18·0	18·1	—
Electrical Resistivity at 20°C. microhm-cm.	108	109	124	115	117·5	132	129
Hardness Ranges, D.P.N.							
Cold-rolled sheet	280 min.	300 min.					
Cold rolled annealed sheet	170–200	190–220					
Solution-treated bar			180–280	180–280	230–330	280–360	
Fully heat-treated bar			250–350	250–350	290–360	320–400	320–400

temperature strength; this modified alloy was called Nimonic 95. An even more advanced alloy known as Nimonic 100 was next produced by introducing some 5 per cent of molybdenum and adjusting the content of other constituents. Nimonic 100 contains less chromium than the other alloys and, in some conditions of very high-temperature running in aero gas turbines, has proved to be subject to certain types of corrosion. To combat this, a basically similar alloy with an increased chromium content has lately been introduced under the name Nimonic 105.

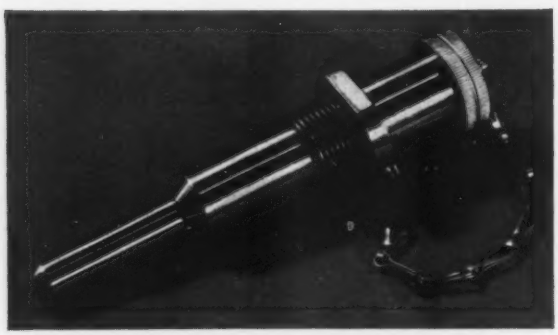
Non-creep-tested Alloys

The Nimonic alloys which are not creep-tested before release are:

1. Alloys notable less for high-temperature strength than for other important properties, such as oxidation-resistance, and not intended for operation under high stresses.
2. Creep-resisting alloys destined for duties where creep behaviour is not of primary importance and creep-testing to specified standards is therefore unjustified.

In the first group are two alloys, Nimonic 75 and Nimonic DS, which are already much used in industry and will grow in importance as their properties become more widely recognised and exploited. Nimonic 75 is basically of the 80/20 nickel-chromium type, stiffened by carbides of titanium. Not only is it exceptionally resistant to oxidation and various other forms of sealing, but it has good mechanical properties at temperatures up to about 1,200 deg. C. and is relatively easy to fabricate Forming by spinning, pressing or rolling is quite straightforward and there are no problems in welding the material by any of the usual methods, provided the correct techniques are followed. Nimonic 75 is a most useful alloy, but in common with all nickel alloys it is susceptible to sulphur attack at high temperatures and may give trouble if sulphur or sulphur compounds are present, to a degree dependent on the surrounding atmosphere. Its use in carbonaceous atmospheres should also be approached with caution, subject to the maker's advice. The creep properties of Nimonic 75 depend largely on the method of manipulation and, as this varies from component to component, "standard" properties are not of great value to the designer.

Nimonic DS differs from other alloys of its kind in having a substantial content of iron and being an improved version of a long-established alloy. It is nominally of the well-known 37 per cent nickel, 18 per cent chromium composition, but with the addition of 2 per cent silicon. Although less resistant to oxidation than Nimonic 75 and the other higher-nickel-containing alloys, it behaves well in oxidising conditions up to 950 deg. C. and in reducing atmospheres at even higher temperatures. Its particular virtue is its resistance to carbonaceous atmospheres and to the form of corrosive attack on nickel-chromium alloys known as "green-rot".



Thermowell made by Honeywell-Brown in Nimonic DS for taking temperature readings in pressure vessels.

Typical Uses

Since these nickel alloys became available to industry some ten years ago, they have found their way into a host of duties in the medium- and high-temperature ranges. Many of these applications are of long standing and the alloys have merely replaced the conventional materials for the job, e.g., stainless steels and cast nickel-chromium alloys. In other cases, entirely new ground has been broken by the design of highly rated or very-high-temperature equipment which takes full advantage of the properties offered by these advanced alloys.

Nimonic 75 and Nimonic DS have been accepted as standard engineering materials for many years and are widely used in production equipment. The majority of Nimonic 75 goes into fabricated components such as furnace muffles, combustion chamber parts, high-temperature fans, enamelling perrits, retorts, carburising boxes and heat-treatment jigs. Its original use—for the flame tubes and hot gas ducting of aero and industrial gas turbines—remains of great importance; indeed, the alloy has been

standardised for these duties for more than fifteen years and is specified by Rolls-Royce, Bristol, Napier, Ruston & Hornsby, B.T-H. and other leading gas-turbine makers. Nimonic 75 is, of course, available in all the usual mill forms, including wire, tube and section. Other applications are high-temperature bolts, heat-treatment trays, thermocouple sheaths, furnace bars, radiant tubes and pouring lips.

Nimonic DS was first developed for wire-woven conveyor belts in furnaces, but this application has since been supplemented by many others. The duties for which Nimonic DS is suitable are in many cases similar to those for Nimonic 75, but it has also become established for various purposes where Nimonic 75 is either unsuitable or unjustified on a cost basis. Examples are pottery-kiln cranks, refinery flare-stack tips, waste-gas burners and the high-temperature parts of domestic paraffin heaters.

To date, the creep-resisting Nimonic alloys have found fewer applications than Nimonic DS and 75, largely because their exceptional strength in certain ranges of temperature cannot be used to full advantage in existing equipment other than gas turbines. Now that the nickel shortage is finally ended and these alloys are no longer in short supply, they are likely to be specified increasingly for a variety of purposes. Already, a number of pointers to the future have emerged from research on high-temperature steam turbines. Both Nimonic 80A and Nimonic 90 have been used successfully for turbine blades, boiler tubes and superheater tubes in experimental steam plants operating at very high temperatures and pressures. One example is the equipment built by the Imperial College of Science and Technology for measuring the enthalpy of steam up to temperatures and pressures well above current practice.

Nimonic 80A was chosen for the boiler and superheater tubing, and for every other part in contact with the high-temperature steam; it allows the use of a maximum pressure of 1,000 atmospheres at 600 deg. C. or 150 atmospheres at 750 deg. C., and shows no signs of corrosion or erosion after many years' service under these extreme conditions. Equally encouraging results have been achieved elsewhere with Nimonic 80A rotor blading in an experimental steam turbine running at up to 75 atmospheres and 650 deg. C. Further evidence of the excellent resistance which Nimonic 80A gives to erosion by superheated steam comes from the aircraft rocket-engine field, in which catalyst support plates machined from this alloy have given good service when subjected to the high-velocity flow of decomposition products from hydrogen-peroxide catalysis. Of more immediate interest to steam-turbine engineers is the use of these alloys for cylinder and other bolts which require high strength in the medium-temperature range.

A group of Nimonic 75 carburising boxes cooling off at the works of David Brown Industries Ltd. Life for this alloy in this particular application is claimed to be more than 100 times that of mild steel.

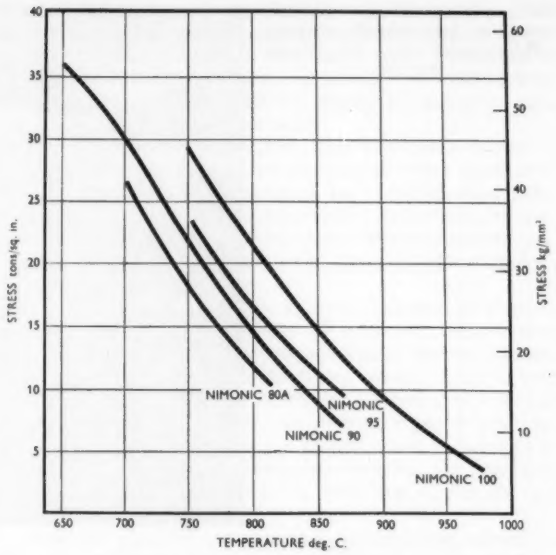


Fig. 1. Stress against temperature curves for rupture of Nimonic alloys in 100 hours.

Other power-plant uses are in diesel engines, where precombustion chambers of Nimonic 80A have lasted many times as long as the alloy steels previously specified, and in long-life industrial gas turbines, where the Nimonic alloys have been widely adopted for turbine blades and other high-temperature parts.

Nimonic 90 is proving a most satisfactory die material for copper extrusion. Billet temperature in this process is about 850 deg. C. and the life of Nimonic 90 is anything up to a hundred times that of high-tungsten die steels. Among other materials which can be extruded successfully through Nimonic 90 dies are the Nimonic alloys themselves. Besides having excellent high-temperature properties, Nimonic 90 is a strong and useful material in the medium-temperature range. Its spring properties are good, Nimonic 90 springs being suitable for relatively high stresses up to 400 deg. C. and for moderate to low stresses up to 600 deg. C. Springs made in this alloy are now standardised in numerous applications and their uses are constantly growing.

The high proof stress, dimensional stability and resistance to abrasion of Nimonic 80A make it an excellent material for the moulds used in making diamond grinding wheels by powder metallurgy. Another characteristic of this alloy—resistance to thermal shock—has made it the standard choice for the die and core material in aluminium-bronze die casting, where the casting temperature is around 1,150 deg. C. In sheet form, Nimonic 80A has not yet been utilised outside the aircraft industry, but the fact that it has been standardised for afterburner structures, thrust reversers and jet-noise reducers by Rolls-Royce Ltd. gives a clear indication of its properties and potentialities.

Wrought high-nickel alloys of the Nimonic series offer a combination of high-temperature properties of great value to engineers. They are now available generally to industry and have already become established in a wide variety of uses which were previously the province of heat-resisting steels and cast nickel-chromium alloys. Nevertheless, these alloys are still new in the engineering sense and there is insufficient realisation outside the aircraft industry of their potentialities. Their introduction has opened up a field of high-temperature performance which remains to be fully explored.

A neoprene-coated asbestos panel is here tested to resist flame penetration for fifteen minutes.

WIDENING APPLICATIONS FOR NEOPRENE

The group of synthetic rubbers called polychloroprene or, more commonly, neoprene, provides the designer with a material that has an almost unique combination of properties giving resistance to corrosion, fire, flexing and weathering

RELATIVELY young as engineering materials go, neoprene, the first of the commercially-available synthetic rubbers, has been on the market for a little more than twenty-five years. In this time, it has found a place in virtually every industry. Its superior properties have resulted in replacing natural rubber and its use for thousands of other applications as well.

The name neoprene describes a family of chemical rubbers consisting of polymerised chloroprene. Neoprene and neoprene latex all possess outstanding resistance to deterioration by oils, solvents and chemicals, sunlight and weathering, oxidation, heat, flexing, abrasion and burning. Each type of neoprene, however, has its own special characteristics which contribute to its usefulness in specific applications.

In making a neoprene product, the rubber goods manufacturer has his choice of any of a number of neoprene polymers and can further modify the properties of the finished product by the choice of fillers, softeners and vulcanising agents. Thousands of different neoprene compounds are available, each with its own particular characteristics.

Optimum performance with respect to all properties cannot be obtained in a single neoprene compound. Obviously, a single neoprene composition cannot be completely tear-resistant and extremely soft. The two characteristics must be balanced with the properties most needed for a particular application, and some softness may be sacrificed in order to give better tear resistance.

Neoprene characteristics may be divided into two general categories, basic properties and resistance to deterioration. The former include hardness, tensile strength, compression set and resilience. Resistance to deterioration covers measurements of the extent to which original properties are retained during exposure to deteriorating influences such as oil, sunlight and weathering, oxidation and heat.

Basic Properties

Neoprene compounds can be obtained having durometer hardnesses ranging from less than 30 to more than 90 and typical commercial neoprene compositions have tensile strengths ranging from 56-280 kg./cm.^{2} The tear resistance of neoprene compounds is of the same order as that of similar compounds of other elastomers.

Compression set is a measure of the elastic recovery property of a composition after condition under a load for a prescribed time at a definite temperature. The lower the compression set, the better are the elastic recovery properties. It is a useful measurement for gasketing and sealing materials, since it indicates the extent to which a composition can be expected to maintain an adequate sealing pressure in service. The data in Table 1 compare the compression set values obtained with a compound made with a general-purpose neoprene polymer and a natural rubber composition designed to have minimum compression set. Note that the neoprene compound is superior to the rubber compositions at all conditioning temperatures.

The dynamic characteristics of elastomers are of importance in such products as vibration isolators, tyres, V-belts and flexible couplings. Among the chemical rubbers this product is generally acknowledged to have dynamic characteristics most closely approaching those of rubber in the practical hardness range.

The curves of Fig. 1 compare the resilience of similar neoprene and natural rubber compositions over a range of hardness. Note that the resilience of the natural rubber compounds is superior to that of the neoprene compositions

only in the low hardness range. As hardness is increased by the addition of fillers, the resilience of the rubber compositions decreases at a faster rate than that of the neoprene compositions. The point at which the two curves cross depends largely on the type of filler used to adjust hardness.

The energy loss in a cycle of deformation (i.e., hysteresis) is dissipated in the form of heat and, since elastomers are not sufficiently good heat conductors to dissipate the heat as rapidly as it is generated, rapid vibration may result in a substantial temperature rise within a compound (Fig. 2). Knowledge of the heat build-up characteristics of a composition is important because (1) the physical strength of all rubber-like materials decreases with increasing temperatures, and (2) the rate of deterioration of a composition due to ageing (oxidation) increases rapidly with increasing temperatures.

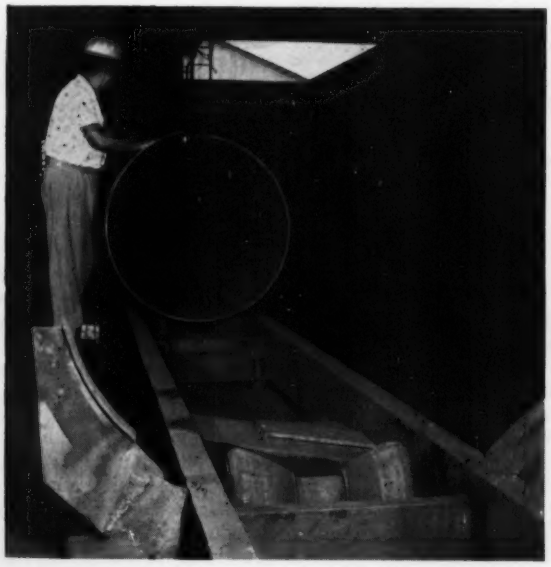
Creep, the increasing deflection of a material under constant stress, is exhibited in varying degrees by all solids. Data comparing the long-term creep characteristics of similar rubber and neoprene stocks are shown in Fig. 3. The initial creep of the neoprene compounds is substantially higher than that of the natural rubber compositions. The slope of the creep curve, however, is considerably higher in the case of the rubber compositions, so that the actual values for the neoprene and rubber specimens approach each other after prolonged conditioning.

Changes in elastomers at low temperatures take place rapidly as soon as temperature equilibrium is established or occur only after prolonged exposure to low temperatures. Rapid temperature changes bring gradual changes in such properties as hardness and resilience within a relatively narrow temperature range which is characteristic of a given composition. The stiffness caused by the gradual changes of temperature may result in brittleness under conditions of impact loading. The highest temperature at which brittleness is noted under definite conditions of loading is commonly known as the brittle point.

Temperature changes affect neoprene compositions in the same way as they do compounds of other elastomers. This is illustrated by the curves in Fig. 4, which show hardness as a function of temperature for compounds of neoprene and natural rubber. On cooling from room temperature to −30 deg. C., the neoprene increased in hardness by about 30 durometer points.

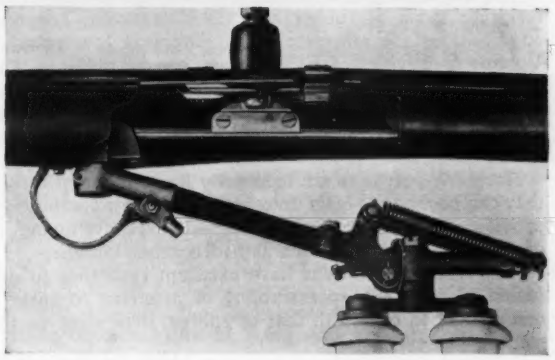
Special compounding techniques can be used to improve the low-temperature flexibility of neoprene compositions and the extent of the improvement which can be obtained by proper compounding is illustrated when a material containing a low-temperature plasticiser is compared with one having no softener. In the case of both types of polymer, the improvement obtained by compounding is substantial. The brittle temperature of the one containing the plasticiser is −54 deg. C. as compared to −40 deg. C. for the one with no softener.

Another effect of temperatures on neoprene as well as natural and butyl rubbers is crystallisation. For each of them there is a temperature where crystallisation takes place most rapidly. This temperature for neoprene is approximately −15 deg. C., while the critical temperature for rubber is reported to be −25 deg. C. The rate at which crystallisation occurs depends on the composition and conditions of exposure. Crystallisation, like other low-tempera-



Above: Rollers of gravity conveyors are a successful application for neoprene. In this case they are used to move a 40-ft. length of pipe between various manufacturing operations.

Top right: This hydrochloric acid tank has been coated with neoprene for more than eight years and, although exposed almost continuously to corrosive materials, it has needed no repairs.



Right: Neoprene has been used for the continuous protective casing of this overhead current collection equipment made by B.I.C.C. Ltd. The casing is subjected to continual flexing.

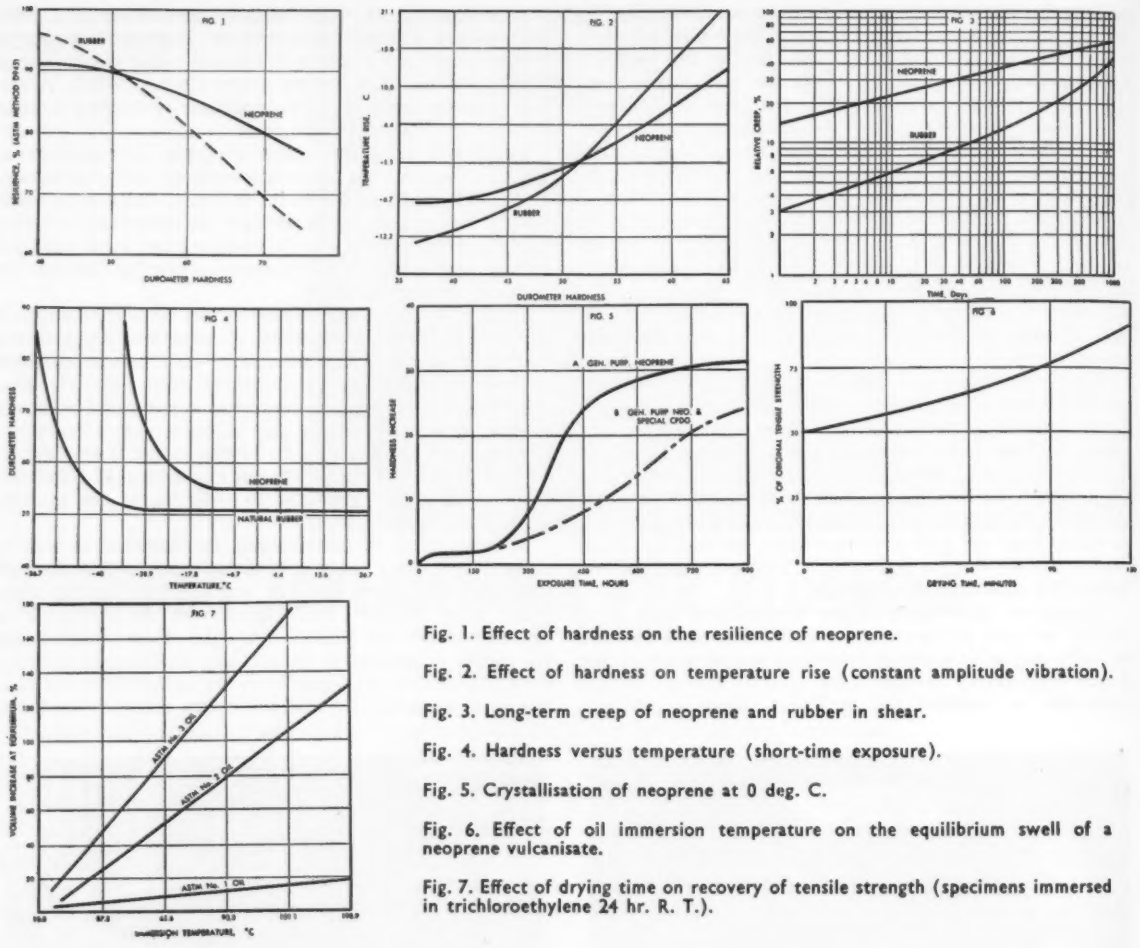


Fig. 1. Effect of hardness on the resilience of neoprene.

Fig. 2. Effect of hardness on temperature rise (constant amplitude vibration).

Fig. 3. Long-term creep of neoprene and rubber in shear.

Fig. 4. Hardness versus temperature (short-time exposure).

Fig. 5. Crystallisation of neoprene at 0 deg. C.

Fig. 6. Effect of oil immersion temperature on the equilibrium swell of a neoprene vulcanisate.

Fig. 7. Effect of drying time on recovery of tensile strength (specimens immersed in trichloroethylene 24 hr. R. T.).

ture changes, is reversible by heating or mechanical working. It can be minimised by using the appropriate neoprene polymer or by proper compounding and curing.

The curves in Fig. 5 show the effect of both methods of approach on crystallisation judged by hardness change during prolonged exposure at 0 deg. C. Curve A shows the crystallisation tendencies of the most commonly used general-purpose neoprene polymer. There is a gradual increase in hardness followed by a fairly rapid increase after about 200 hours of exposure. Curve B shows the effect of special compounding on crystallisation of the same neoprene polymer. A comparison of curves A and B demonstrates that both the rate and extent of crystallisation have been decreased by proper compounding.

The dielectric properties of neoprene are somewhat inferior to those of rubber and GRS. However, neoprene compositions are adequate as insulators at low voltages. Volume resistivities of 10^{12} ohm cm. can be obtained with insulation-type compositions. Conductive compositions also can be made having resistivities as low as 10^{3} ohm cm. The dielectric strengths of typical commercial neoprene stocks range from 150-550 volts per mil.

Neoprene polymers are inherently flame resistant. While they can be made to burn, they will not support combustion, provided they are not compounded with excessive quantities of flammable materials such as hydrocarbon softeners.

Neoprene compositions have excellent resistance to diffusion of gases. The permeability of neoprene to gases is one-quarter to one-tenth that of rubber, depending on the gas.

Resistance to Deterioration

The chemical nature of the immersion media, service temperature, ratio of exposed area to total volume of part and type of service are the four most important factors determining how oils, solvents and chemicals affect neoprene.

Very small differences in chemical compositions can bring about different effects on elastomers. Lubricating oils, of the same S.A.E. viscosity grade, but obtained from different crudes, may have, for instance, significantly different effects. This is illustrated by the data in Table 2, which show the equilibrium volume increase of a neoprene composition after immersion at 100 deg. C. in S.A.E. 20 lubricating oils from different crude stocks. The data show that substantial differences are obtained with oils of different chemical type and even with different oils from crudes of the same general class.

The effect of temperature is another factor of importance in determining the suitability of neoprene for a given service. This is illustrated in Fig. 6, which shows the equilibrium swell of a neoprene composition in each of three oils over the temperature range of 24-149 deg. C. The immersion media were chosen to simulate the effects of a wide range of petroleum derivatives. As would be expected, volume increase is proportional to temperature for any given immersion medium. The slopes of the curves, however, are quite different. A comparison, then, of the effect of two oils at one temperature does not permit accurate prediction of their relative effects at some other temperature.

Whether or not a neoprene product is in continuous or intermittent service is especially important in applications

TABLE 1. Compression set—neoprene versus rubber

	Compression set at		
	70 deg. C.	100 deg. C.	121 deg. C.
Neoprene, %	13	18	20
Rubber, %	20	28	38

Specimens conditioned at 30 per cent deflection for 70 hr.

TABLE 2. Swelling effect of S.A.E. 20 lubricating oils at 100 deg. C.

Chemical type	Volume increase per cent.
Paraffinic A	13
Paraffinic B	29
Naphthenic	62

involving contact with the many highly volatile materials such as benzene and trichloroethylene, which are widely used as chemical process intermediate solvents and degreasing agents. Even though continuous contact with trichloroethylene, for example, may result in substantial deterioration of a neoprene composition, the same contact may be satisfactory for intermittent contact with this solvent. The intermittent contact allows time for evaporation of highly volatile hydrocarbons, so that the compound rapidly regains its original properties. The speed with which physical strength is regained is illustrated in Fig. 7. This curve shows the effect of drying time on the tensile strength on a neoprene composition after immersion in trichloroethylene for twenty-four hours at room temperature.

Tensile strength of the composition, measured immediately after removal from the solvent, was only 50 per cent of its original value. After two hours of drying time, it returned to 90 per cent of its original value.

Neoprene compounds usually render excellent service in contact with (1) all straight chain hydrocarbons even when substantial amounts of aromatic constituents are added, as in some types of aviation gasoline; (2) all aliphatic hydroxy compounds such as methyl and ethyl alcohols and ethylene glycol; (3) animal and vegetable fats and oils; and (4) fluorinated hydrocarbon compounds. These compounds are either unsuitable or have limited serviceability when used in contact with (1) chlorinated hydrocarbons such as chloroform and benzylchloride; (2) organic esters such as butyl acetate and methyl salicylate; (3) aromatic hydrocarbons such as toluene and benzene; (4) aromatic hydroxy compounds such as phenol and cresol; and (5) some ketones, especially mixed ketones, such as methyl ethyl ketone.

Generally, neoprene compositions render excellent service even at elevated temperatures in contact with (1) dilute mineral acids, except those of a strong oxidising nature, (2) all alkalis including concentrated sodium and potassium hydroxides, and (3) all solutions of inorganic salts except those of a strong oxidising nature. Neoprene is unsuitable or has limited serviceability in contact with strong oxidising agents such as nitric acid, potassium dichromate, concentrated sulphuric acid and hydrogen peroxide. In cases where the suitability of neoprene is doubtful, the use of simulated or actual service tests is recommended before adopting its use.

The outstanding resistance of this product to chemicals, sunlight and weathering, ageing, ozone, heat and flame has been demonstrated through laboratory as well as actual use tests many times during the quarter of a century it has been in existence. Today, this versatile elastomer is giving efficient service in thousands of different products. It has been used for curb pump hose at service stations for a number of years, as well as in some forty different types of hose in the U.S. Navy. In these applications the combination of oil and chemicals resistance and resistance to ozone and ageing is particularly useful. Resistance to both heat and abrasion is best demonstrated by conveyor belts which carry millions of tons of hot coke annually. The fact that safety authorities are now specifying it for wire and cable jacketing in mines and plants throughout the world testifies to its flame-resistance. The excellent weatherability of neoprene has resulted in its almost universal use as a covering for electrical wires by utilities throughout the world.

Coatings of neoprene protect against corrosion, weathering, chemicals, or whatever the need may be. Its low compression set has resulted in widespread use in gaskets and seals of all types.

ACKNOWLEDGEMENT

We wish to acknowledge with thanks the major contribution made to this article by **E.I. Du Pont de Nemours & Co.**

LINING TANKS WITH EPOXY RESIN BASED PAINTS

A METHOD of lining a number of mild-steel tankers with epoxy resin-based paints is reported in the house magazine of W. P. Butterfield Ltd. by the company's chief engineer, Mr. W. L. Richardson.

After shot-blasting the inside surfaces of the tanker, all traces of residual shot or dust are removed. As atmospheric moisture alone is sufficient to cause a film of rust after shot-blasting, the first coat of paint has to be applied with as little delay as possible.

To ensure complete coverage by each of the four coats, the first and third coats are tinted pale blue, the second and final coats white. After each coat is applied it is allowed to cure at room temperature for a given period, followed by a further period at roughly 60 deg. C. This temperature is maintained, within limits, over the whole of the period for which the coating is being heat cured, and evenly over the whole surface. Experiments were carried out with various kinds of apparatus in an effort to attain the required conditions, and eventually a thermostatically-controlled oil-fired air heater was installed. The hot air was then supplied to the job by means of a ducting provided with "tappings" from which the hot air could be piped to the compartments being treated.

During the heat-curing operations the tanker's body is upside down to enable the spray operator to work standing on the shop floor with his head, shoulders and arms protruding through the manhole. This allows him to work back towards the manhole and withdraw easily as he finishes his work of spraying the manhole neck.

Nevertheless, at various stages in the shot-blasting, and particularly in the subsequent cleaning, the tanker body has to be turned about its longitudinal axis.

The surface produced by the epoxy resin-based paint is something akin in appearance to that produced by the process of vitreous enamelling on cast iron. However, whereas enamelling chips very easily, the lining produced by the resin-based paint has considerable flexibility. Lined tanks slightly damaged by minor indentations can usually have these indentations removed without damage to the lining and without dismounting from the chassis.

While not resistant to all concentrations of all acids and alkalis at all temperatures, the resistant properties of linings of this material are quite satisfactory for a large range of commodities such as aviation spirit, acetic acid at low concentration and room temperature, sulphuric acid up to 10 per cent concentration, at room temperature, sea water and oils. It is therefore well worth while considering the possibility of using such lining for the construction of the tanks.

CASTING POROSITY ELIMINATED BY RESIN IMPREGNATION

by P. D. YOUNG*

DURING the past fifteen years many thousands of castings, ranging in weight from a few ounces to a few tons, in ferrous and non-ferrous metals, have been impregnated against porosity. They include small items for domestic and general purposes, medium-sized components such as cylinder heads, crankcases, filter bodies, carburettors, gearboxes, machine tool beds and water turbines, and large parts such as rollers for paper-making machinery, pipes for oil lines, bottling machines and large tube castings, etc. The charges are only a fraction of lost man-hours and costly machine-hours. No further machining is required after impregnation, and tolerances are unaffected.

The design of modern castings has increased the problems of porosity, particularly in the aircraft industry where the design is limited by the weight and size factor. The process of impregnation is approved by the A.I.D., A.R.B., the Admiralty, the Ministry of Supply and the Atomic Energy Authority.

The resins employed are of a high solids content, and are unaffected by petrol and oil up to 250 deg. C., hydraulic fluids, ethylene glycol and other solvents. They have also withstood tests against modern types of high explosive, but the impregnation of castings that are subject to hot caustic solutions is not advised.

PRESERVING AND FINISH—The impregnation of castings prior to stove enamelling is of great value as a prevention against blistering of paint, caused by the expansion of air in the pores of the metal. The resins employed in this field are of high viscous and thermo-setting types, which are used as a surface impregnation only. Similarly, impregnation is valuable in the prevention of plating failures. Porous areas have a tendency to absorb plating and cleaning solutions; these exude and "spot out" after the plating cycle is complete. This problem is particularly serious in the powder metallurgy field, a typical example being an adding machine for which it was found impossible to cadmium-plate successfully pinion gears of sintered iron. The parts were plated by approved methods, but were badly corroded after ten days' exposure on test. When these parts were impregnated before cadmium plating, they showed no evidence of corrosion after a five months' test.

A group of castings showing the extensive variety of all sizes that can be treated by resin impregnation.

SPECIAL APPLICATIONS—The service for reclaiming castings which are to be pressure tight is regularly used by many firms in this country. Among these may be mentioned Vandervell Products Ltd., who acknowledge the success of the Vanwall racing cars was greatly helped by impregnating cylinder heads against porosity.

In a recent instance, it had been discovered that cutting fluid on the beds of finished machine tools had eventually penetrated the castings. Treatment with cold-setting resins overcame this. Larger castings may be treated on site.

PREREQUISITE FOR TREATMENT—It should be emphasised that no casting structurally unsound should undergo impregnation treatment. The presence of cracks also renders the casting ineligible, though, of course, these may be dealt with first by other techniques to render the casting acceptable. Blow holes, if not on a surface which has to engage another surface, can be filled with special mixtures of resins and metallic powders.

Methods of Treatment

Two principal methods of treatment are employed. Small castings, after thorough cleaning and dehydrating, are placed in an autoclave and the air removed by vacuum pump from the autoclave and pores in the castings. Without breaking the vacuum, the impregnating material is forced by compressed air into the evacuated pores of the castings. Pressure is released, and the castings are removed and cleaned. After cleaning, the liquid impregnant, which has been absorbed into the structure of the metal, is solidified by drying, baking or curing.

Using a batch-type vacuum pressure system and a modern type of impregnant, a properly impregnated casting can be pressure-tested to destruction without any leakage. Experimental magnesium and aluminium castings have been proof tested in this way. Bronze castings have been successfully tested under hydraulic pressures as high as 6,000 p.s.i. without producing leaks in sections that were known to be micro-porous.

A second method is employed principally for larger work. All openings in the castings are blocked except one, which is connected to a vacuum pump. Reduced pressure inside the casting results in the impregnant being drawn into the pores of the metal.

DEVELOPMENT—Current development work is being directed particularly to faster treatment cycles and impregnants to resist high temperatures.

*General manager, Industrial Impregnations Ltd.

NEW IDEAS IN DESIGN

Outstanding products in current manufacture

Template-controlled Milling Machine

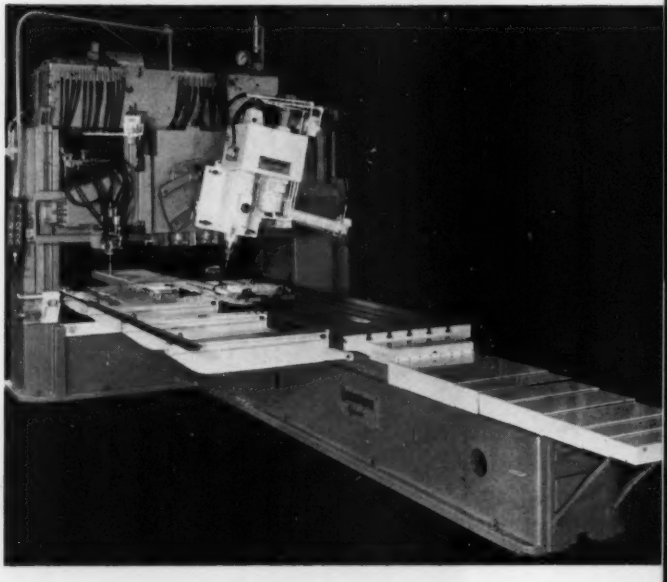
A NEW machine for swarfing the joining edges of parts or sub-assemblies having compound surfaces is being produced by Rockford Machine Tool Co. Swarfing is the operation of warp- or twist-milling the edges to facilitate the accurate mating of surfaces, particularly in the aircraft and guided missile industries.

This 3-D Hy-Draulic swarfing mill is claimed to combine the versatility and efficiency of hydraulic drive with speed and ease of manual stylus control. The swarfing head consists of a slide with square-sectioned arc ways which is bolted to the face of the duplicator slide. Moving on these arc ways is the swarfing saddle which is moved by a trunnion-mounted cylinder. An electronic single-axis tracer mounts on adjustable slides on the left-hand column. The tracer stylus is positioned by a thin template held on template support brackets and converts the mechanical information received from the template to an electrical signal. The electrical energy thus obtained is used to position an electro-hydraulic servo-valve which controls the flow of oil to the cylinder. A second electronic tracer is located on the swarfing saddle to feed back electrical information to the servo valve so that angular positioning is maintained.

A simple and accurate device is incorporated in the upper arc way to lock the head in a neutral position when the swarfing motion is not in use. Alternatively the swarfing motion may be used simultaneously with any combination of vertical, transverse or longitudinal movement, without any template compensation. For a combination of these movements, using full-size wood, plaster, plastics or metal full-form masters or templates, a simple manual stylus control is employed. The operator is thus able to keep the milling cutter in full view and have complete control of the feed rate of the machine at all times.

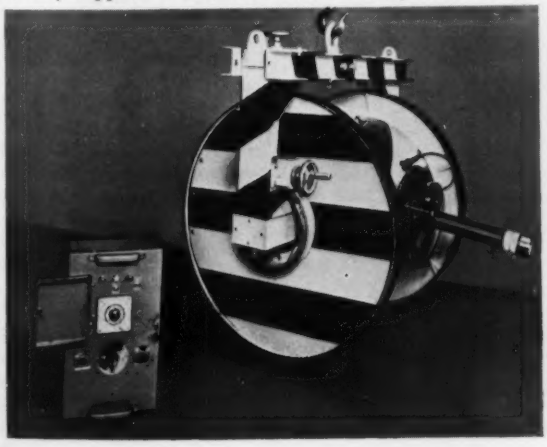
The machine has two valves. One is a three-dimensional tracer valve mounted on adjustable slide for longitudinal, cross and vertical adjustments, for varying the relationship between the cutter and the stylus. The other is a servo-valve arranged with four-position turret stop for variable depth control in 360-deg. contour operation. To prevent damage to the machine or operator, electrical and hydraulic interlocks are provided between the two valves. The milling head is mounted on a vertical slide and is water cooled. Longitudinal, cross and vertical milling feed rates from 0 to 50 in./min. are provided, with traverse rate of 85 in./min. The massive proportions of the machine enable the machine to be used on ferrous materials.

The machine table is available in three sizes, the largest of these being 42 in. x 24 in. with a stroke length of 12 ft.



Portable High-intensity Cobalt Container for Industrial Radiography

NEWTON-VICTOR LTD., the X-ray department of Metropolitan-Vickers Electrical Co. Ltd., have recently supplied a cobalt container which, with a source of 1,500 curies, is believed to be the most powerful in industrial use in the world. It is intended for the radiographic examination of welded seams in steel plate up to 5 in. thick. The protective container is housed in a steel cylinder which can be rolled on its steel end-flanges over rough ground. A steel supporting fork is provided for slinging the unit from a crane or, with the angulating gear disengaged, for hauling the equipment up a loading ramp on to a vehicle. These features render it particularly suitable for work on large construction sites, especially if these are located in remote areas. Small currents are necessary for control purposes only and the quality of the radiograph is not dependent on the maintenance of precise voltages and frequencies. No water or oil cooling is necessary.

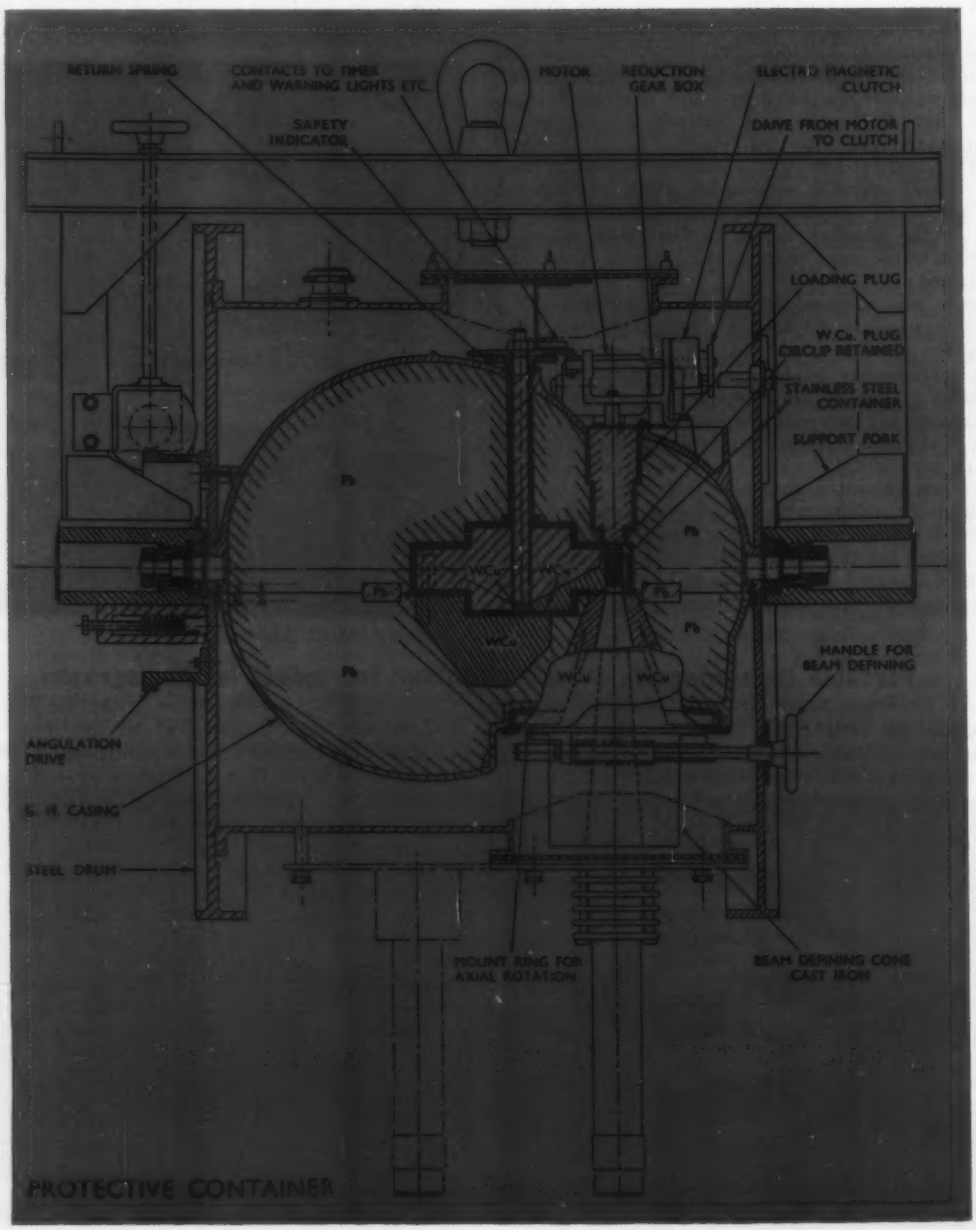


The cobalt source is housed in a lead and heavy alloy protective container thick enough to reduce the intensity of the radiation at the surface to 6·25 milli-roentgens per hour. Instead of the source being moved from the "protected" to the "exposure" position manually, as is the case with some systems, the source is in this instance housed at the periphery of a disc which moves through 180 deg. In this way adequate clearances are possible without any

loss of protection, as the source wheel is totally surrounded in all positions by the lead and heavy metal protective shield. The source wheel is driven by a motor against a mechanical stop, thus eliminating the wear and inaccuracy of latching contacts. A magnetic clutch between the motor and the source wheel ensures its immediate return by means of a lightly loaded spring if the electricity supply is interrupted. Interchangeable diaphragms of tungsten copper alloy provide a beam of radiation 6 in. or 12 in. wide and 5 ft. long at a distance of 12 ft. from the source. During the setting up of the container, a simple light projector is used to indicate the position of the beam on the specimen at distances up to 20 ft. When not in use the projector may be swung out of the way, or, for transportation, completely detached. A sheet steel control box for wall or desk mounting incorporates the exposure timer, shutter control, signal lamps, master switch with removable key and 150 ft. of three-core cable.

An exposure is initiated by pressing a button. The source moves from the "protected" to the "exposure" position and starts the synchronous motor timer which has a range of one second to 55 min. in steps of one second. Signal lamps indicate the position of the source at all times. All of these lamps may, in the event of power failure, be operated by long-life batteries included in the control system.

When operating the unit, the operator may retire behind a concrete wall 9 in. thick to work the control, or this may be situated 100 ft. or more away, in which case a wall is not necessary. Additional signals and interlocking relays, to prevent unauthorised entry to the exposure area, can easily be connected to the control.



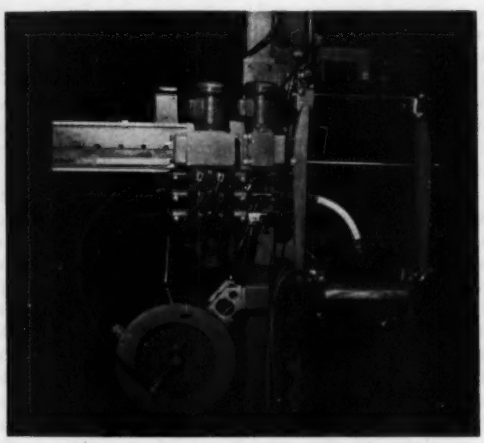
New Welding Machine for Heavy Plate

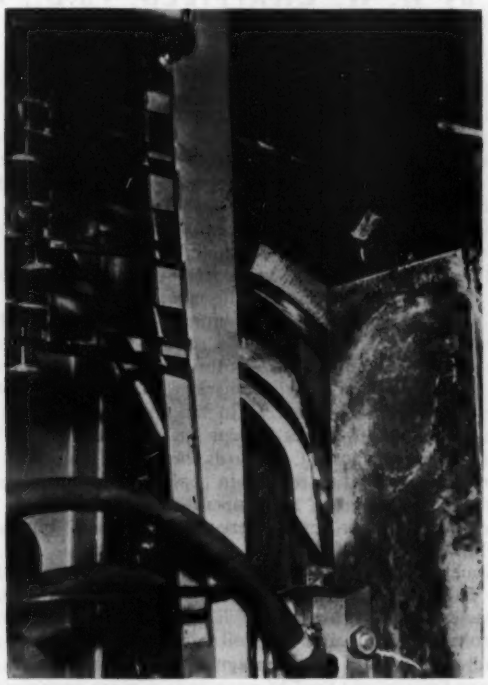
THE Vertomatic, a vertical slag-welding machine now manufactured in this country by Rockweld Ltd. according to patents held by Vus (Bratislava), is claimed to provide considerable economies in the welding of heavy fabrications in plate thicknesses of 2 in. and upwards. As plate preparation is eliminated, a smaller quantity of weld metal is required. It eliminates multiple passes with associated deslagging and chipping. Reduction in the use of flux powders and the high thermal efficiency of the process, resulting in low energy consumption, are further features making for economy.

Plates to be butt welded are arranged in a vertical position with a relatively small gap between the plate edges (1¼-1½ in.). The electrode wires are fed downwards through curved wire guides into the gap. Molten weld metal and slag are retained in the gap by water-cooled copper shoes which ride on the faces of the plates and are traversed upwards as welding proceeds. This traversing is entirely automatic in relation to the level of the solidifying weld metal. The wire guides oscillate in the gap and so distribute the metal evenly. Radiographic results of the welds produced are claimed to be perfect, the mechanical properties obtained without heat treatment being considerably in excess of those required for normal structural work.

The process is also claimed to be applicable to circumferential welds on heavy cylindrical work, and a variety of material compositions can be deposited by the use of special composite wire.

A vertical butt weld between two plates, 2¾ in. thick and 13 ft. long, which would have occupied four welding operators using normal preparation and hand welding one week, is claimed to have been carried out in four hours.



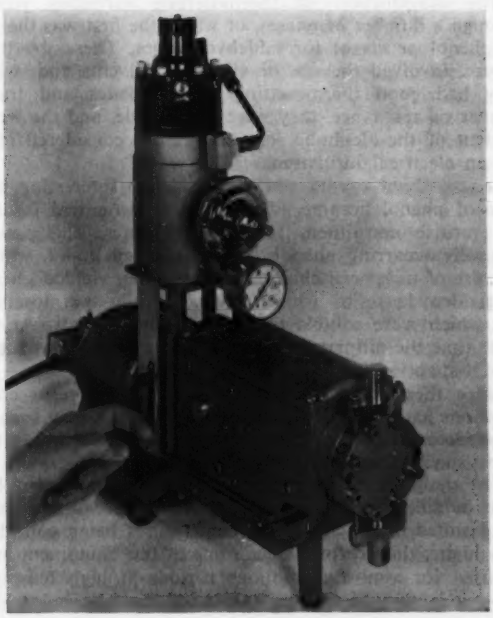


Air-controlled Metering Pump

THE Microflo Pulsafeeder, recently announced by the Lapp Insulator Co., has been designed to give the process industries a simple means of automatically metering chemicals.

Output of the pump from 0-100 per cent is controlled by air pressure variation from instruments with a range of 3-15 p.s.i. In operation, an air cylinder is integrally mounted above the stroke adjustment mechanism. Variations in air pressure (controlled by the sensing instrument) determine the position of a piston within the air cylinder. Change in piston position is mechanically transmitted through a cam to the stroke-adjusting mechanism which controls pump output. Built into the air cylinder is a "positioner" that achieves rapid loading and unloading of the air cylinder to give immediate, accurate push-rod positioning, in response to instrument air pressure.

A reciprocating piston within the pump forces oil to move a diaphragm forward and back. The back stroke takes the liquid chemical into the reagent head through suction check valves. The liquid is forced through the discharge valves on the forward stroke.



NEW MATERIALS FOR INSULATING VARNISHES

The need for higher performances often under exacting conditions has resulted in new ranges of insulating varnishes with outstanding corrosion resistance

by H. W. CHATFIELD, Ph.D., F.R.I.C., M.I.Chem.E.

INSULATING varnishes are used for the impregnation and protection of a large number of different types of electrical equipment, which include chokes, transformers, coils, stators, rotors, etc. Other types of varnish are used for the production of insulating sleeving and varnished cloth and paper.

Like most industrial organic coatings, insulating varnishes have undergone considerable changes in the last thirty years. One of the most striking changes has been the production of essentially thermosetting types.

The older types were often bituminous blends or oleo-resinous types which assumed a solid or semi-solid state, completely or mainly by loss of solvent. At the temperatures employed for stoving these varnishes in industry, little change, if any, occurred in the physical condition of such oleo-resinous types except on the outside of the impregnated component. Towards the centre the insulating varnish would tend to remain in a plastic condition which would be susceptible to temperature changes, and re-liquefaction might be observed. Plasticised bitumens would behave similarly.

Liquefiable or non-thermosetting insulating varnishes thus had a number of defects, such as inferior bonding characteristics, "throwing" of liquid varnish (when used on rotors), poor water and oil resistance and, also, the liquid condition of the impregnating varnish at elevated temperatures would tend to encourage a more pronounced attack on the enamel of enamelled wire.

The introduction of thermosetting varnishes passed through a number of phases, of which the first was the use of phenol or cresol formaldehyde types. These, by their nature, involved the use of alcoholic solvents and, while they had good thermosetting characteristics and transformer oil resistance, they were very brittle, and the water content of the alcoholic solvent was not considered ideal for an electrical insulation.

It was about twenty years ago that an interesting new type of phenol became available as a recognised insulating varnish constituent for the first time. This was a naturally-occurring phenol, cashew nutshell liquid, which, because of its special chemical constitution, yielded phenol formaldehyde resins which were not only thermosetting but which were soluble in hydrocarbon solvents. At the same time the ultimate product when thermoset was tough and resilient and not brittle.

Since then many other types of synthetic resin combinations have become available and the insulating varnish manufacturer is now able to tailor-make varnishes for many specific purposes with special properties.

The design of some types of electrical equipment has been modified for technical and economic reasons, which has resulted in the operating temperatures being considerably higher than before. Since some of this equipment may be used for almost continuous periods at high temperatures, it is obvious that the insulating varnishes must also withstand these elevated temperatures without disintegration or undue embrittlement.

Insulating varnishes with useful operating lives in the temperature range of 150-200 deg. C. are now available. Where such high-temperature performance is required in electrical equipment this means that not only must the impregnating and enveloping varnishes as such be carefully prepared and selected for the purpose, but the other individual components in the equipment must give comparable performances. Because of this, varnished cotton tape used for interleaving or binding has been replaced by varnished glass fabric. The modern high-temperature varnishes for glass fabric would include both silicone and polyurethane types, and these give much better heat resistance than the drying oil types.

It is fortunate that the demand for impregnating insulating varnishes with enhanced properties has coincided with the introduction of wire enamel having improved solvent-resisting properties. Because oleo-resinous enamelled wire is cheaper than the synthetic enamelled type there is still an inclination to use it wherever possible. It sometimes happens that the insulating varnish manufacturer is called upon to produce varnishes with the highest level of properties, and also to be accommodated by oleo-resinous enamelled wire without damaging its enamel. With the great variety of raw materials and intermediates now available to the varnish manufacturer, even these problems are not always insoluble.

For many years it had been necessary to convert the non-volatile constituents of oleo-resinous impregnating varnishes to as high a degree of polymerisation as possible during the actual manufacture of the varnish, because it was known that little further change could be expected during the stoving treatment to which an impregnated electrical component would be subjected later.

Varnish Solvents

This meant that the non-volatile constituents of the varnish were in a very viscous, if not semi-solid, state at normal air temperature, and as such were impossible to use. This difficulty was overcome by the addition of volatile solvent which enabled the varnish to be reduced in viscosity to a condition low enough for easy penetration into the windings of coils, etc. Time has seen the replacement of turpentine with its possible corrosive activity on copper by the more inert white spirit. This solvent, although an improvement, was not ideal in that its evaporation rate was low and it was very difficult indeed to remove it from the inner windings of an impregnated component. Since the outer portions of the varnish on an impregnated component lose their solvent preferentially during the stoving process, and undergo simultaneous hardening by oxidation and polymerisation, it becomes progressively difficult for the residual solvent in the varnish more remote from the surface to diffuse through this

hardened outer layer, and it is not uncommon to find white spirit still entrapped inside even after periods of stoving of 12-15 hr. at 120 deg. C.

In the modern insulating varnishes this difficulty has been largely overcome by the use of more volatile and lower boiling hydrocarbon fractions than white spirit.

For a large number of purposes solvent-bearing varnishes of this improved type give a satisfactory performance, but for very exacting conditions still further improvements have been effected. It is obvious that, if an insulating varnish contains a substantial amount of volatile solvent that will eventually be removed from the finished component, an electrical component which initially was fully impregnated will tend to be less so when the volatile solvent disappears. As the amount of volatile solvent in an impregnating varnish may be as high as 50 per cent of the varnish itself, the possibility of appreciable void formation is a notable risk. The presence of voids in an impregnated component means easier ingress of moisture, development of local hot spots because of poor heat transference, and the possibility of chemical breakdown because of ionisation of the entrapped air.

The problem has been to eliminate these voids, and this was largely achieved by developing varnishes which contained no volatile solvent at all. Thus, apart from the possibility of some draining of varnish from the outside of the treated component, the varnish originally pushed into the inner windings remained there at the end of the stoving period.

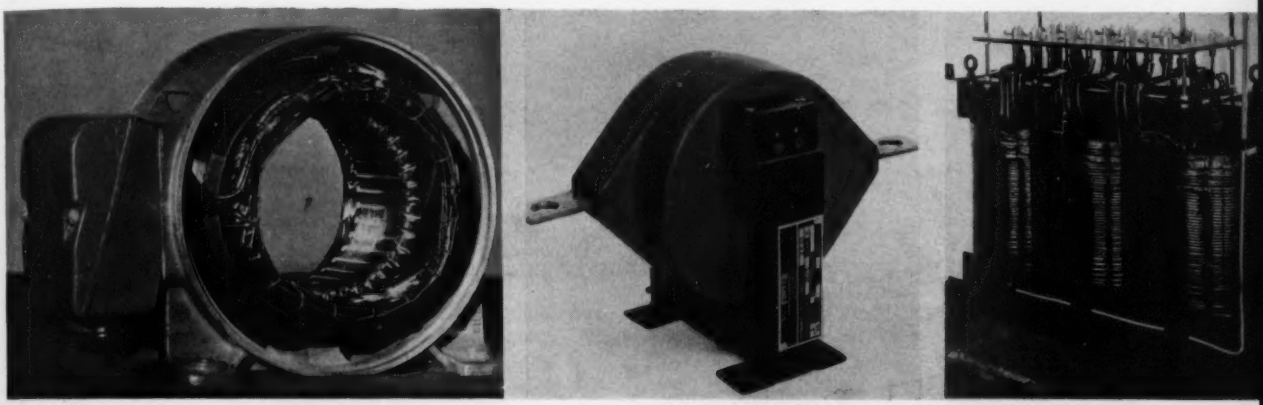
High-performance electrical insulation cannot be achieved unless the insulating varnish effectively penetrates and fills all the air space in electrical components. For tightly wound coils, transformers and similar equipment using fine gauge wire, this needs the assistance of a vacuum and pressure autoclave regardless of whether the varnish is thinned (as in the solvent-bearing types) or is more viscous (as in the solventless types).

Very many electrical manufacturers these days have suitable vacuum-pressure autoclaves. These are employed first in the vacuum stage to remove all retained air in the component, which otherwise acts as a cushion and prevents complete penetration of the varnish, and second in the pressure stage which pushes the varnish through all the narrow channels and interstices from which air was previously expelled. The use of the vacuum-pressure technique is most necessary for the more viscous solventless types of varnishes, because only partial impregnation would be effected otherwise. Using pressures of about 60 p.s.i., it is possible to obtain very satisfactory impregnation with quite viscous solventless varnishes.

For electrical equipment to be subjected in use to conditions of high humidity and tropical temperatures, it is often necessary to envelop the varnish-impregnated equipment with one or more coats of enveloping or finishing varnish. For exceptional service conditions as many as three or four coats of varnish may be applied.

These enveloping varnishes have to provide residual coatings of maximum thickness for each dipped application, with a very high degree of water resistance and, where required, of transformer oil resistance. Because of the wide choice of raw materials available, they do not conform to a single pattern, but in the main they too are based on thermosetting combinations.

To avoid the multi-coat application of enveloping varnishes which consumes considerable processing time—for each coating of varnish is applied and stove dried individually—a good deal of attention has been directed in recent years to the possibilities of casting compounds. Broadly, the impregnated component is sited in a mould and the liquid casting resin mixture is then poured round it. The whole is then maintained at a suitable temperature when the casting resin mixture sets to a hard, tough state. The component is then removed from the mould, surrounded with a heavy protective coating, and this is achieved in a single operation.



Typical uses of insulation. *From left:* Stator of a Brook motor after dipping and baking; Foster high overcurrent factor current transformer cast in filled epoxy resin; Foster 20-kVA. transformer enveloped in a black varnish for moisture protection.

The casting compounds most widely used these days are the epoxy resin types which are mixed with a variety of accelerators in order to ensure conversion to a tough, thermoset condition. The epoxy resins are far more expensive than the usual enveloping varnishes, but this has been minimised to some degree by mixing into them quite substantial amounts of cheap inert mineral fillers. By careful choice of epoxy resin, accelerator, and filler, and adjustment of proportions a heavy protective coating is obtained which gives a very good performance over a wide temperature range, e.g., from −40 deg. C. to +120 deg. C.

Of special importance is the resistance to cracking at −40 deg. C. which may be achieved, and the good maintenance of insulation resistance at temperatures of the order of 110 deg. C. The next step in the development of insulating varnishes is clear, i.e., the development of a casting composition and a suitable processing technique which will enable both impregnation and envelopment to occur simultaneously.

Because of the very wide selection of raw materials now available to the insulating varnish manufacturer, it is possible to manufacture varnishes for special purposes with outstanding chemical and solvent resistance. Thus, for example, electric motors are often expected to operate in all sorts of locations in industry where they may be exposed to corrosive chemicals as dusts, liquids or vapours, and to a wide variety of solvents.

NEW DEVELOPMENTS IN PRECISION TUBES

A review of some of the less-common types of precision tubes and tubular components available to the designer for special applications

by N. M. STOCKTON*

MOST people tend to think of a tube as a long, narrow cylinder. In fact, a tube can be almost any shape, and beyond saying that it started life with the hole down the middle it is almost impossible to define the modern precision tubular component.

Straight tubes can be obtained in a range of 2,000 stock sections, from simple "D" and oval shapes to complicated section that may be used for anything from the deep boring of castings to a structural member in a lightweight diesel car. In addition, a wide range of manipulation processes which may taper, bulge, reduce, expand, flange, dome, lap, butt, bead, trap or carry out any other of a dozen more operations on the tube, or combinations of those processes, shows the tremendous versatility of the modern precision tube.

Developments in recent years have made possible the production of tubular components that could not have been made before. In some instances, that has been brought about by the development of new plant which has added an entirely new process to the tube-maker's resources. In other cases it is more a development and extension of older techniques, so that by improved tooling and closer technical control the limits of a process have been considerably extended. Whatever the explanation, the result in both cases is that the modern designer can often achieve a degree of accuracy and economy from a tubular component not obtainable in any other way.

An example of a new process—at least in this sense—is the development of cold impact extrusion for the production of longitudinally-finned tubes in pure aluminium, aluminium alloys and magnesium alloys. These have been developed for fuel element cans in gas- and water-cooled reactors, the fins providing the most effective means of heat removal from the hot uranium bars which are housed in the cans. If desired, the fins can subsequently be formed into a spiral.

An example of a new development stemming largely from the improvement of traditional techniques is the production of special thin-walled tubing. Cold-drawn seamless thin-walled stainless-steel tubes can now be successfully produced in diameters up to 4¼ in., with thicknesses down to 0·010 in. In smaller diameters of approximately ½ in., tubing has been made with a wall thickness of 0·004 in., and smaller tubes can be made with even thinner walls.

Successful development work has also been carried out in the manufacture of large-diameter thin-walled tubes from welded and drawn strip. One size recently produced in Nimonic 75 measured 8 in. o.d. by 0·015-0·020 in. thick by 54 in. long.

The production of thin-walled tubing, in turn, made possible the introduction of helically-convoluted flexible tube. These seamless flexible tubes are obviously more satisfactory than the fabricated type and have been used to overcome design difficulties in such applications as aircraft fuel pipes. Even on low-cost work, the speed of assembly which can be achieved with flexible tubing, compared with the time and trouble needed to form non-standard bends in normal tube, may well make it an economic proposition.

A standard range of flexible tube sizes has been agreed, ranging from $\frac{3}{16}$ in. to 3 in. nominal bore size, and the tubes have been produced in austenitic stainless steel, Inconel, titanium, zirconium, mild steel and non-ferrous alloys.

Another development from thin-walled seamless tubing is the production of flexible joints, bellows, etc., with annular convolutions.

More development work has led to the introduction of a forming technique for producing helically-gilled tube used in heat exchangers. Such tubes can give a surface area ratio in excess of six-to-one compared with a plain tube of the same diameter as the gill root, and, moreover, the gills are integral with the tube wall.

Very small precision tubes have also been developed and what may be the world's smallest seamless tube now stands at 0·0014 in. o.d. Such a tube has been used for the arti-

* *Accles & Pollock Ltd.*

ficial insemination of queen bees!

Tubes in this hypodermic-needle range find many applications. A size of 0·010 in. o.d. with a wall thickness of 0·001 in., made in aluminium, is used by makers of scientific instruments to provide a pointer which combines a low moment of inertia with the required strength. Pairs of tubes, operating one inside another, with ends machined to form a needle eye which can rapidly open and close are used in textile machinery.

Tube production becomes difficult when the ratio of inside diameter to outside diameter becomes extremely high or extremely low. At the one end of the scale are the thin-walled tubes already mentioned. At the other end are thick-walled tubes, used in high-pressure applications, where the inside diameter may be only a tenth of the outside diameter. Such tubes have been successfully produced to meet requirements as high as 200,000 p.s.i.

Composite Tubes

Composite tube is made from two or more dissimilar materials drawn together to form a single tube. Normal composite tubing has a mechanical bond, but experiments are proceeding in the drawing of composite tubing from dissimilar metals bonded metallurgically. Composite tube has been made in such materials as mild steel and stainless steel, copper and silver, mild steel and copper, stainless steel and cupro-nickel, and mild steel with Tufnol, Paxolin or polyvinyl chloride.

Multi-bore tubes are made by sheathing a number of smaller tubes with a larger tube drawn down tightly on to the inner tubes. It is possible by the use of special techniques to fill the spaces between each of the inner tubes completely.

Designers of both conventional aircraft and helicopters have recently demanded tubes with extreme tapers in the wall thickness. These have been produced by a combination of drawing and machining techniques, with consequent large savings over machining from solid blanks. One such tube, used in the Fairey Rotodyne, will serve as an example. Overall length of the tube required was 13 ft. 6 in. with a diameter of 2·980 in. The gauge variation consisted of 10 in. at 0·315 in. thickness at the root end, tapering over $2\frac{1}{2}$ in. to 0·160 in. thickness, parallel for $8\frac{1}{2}$ in. at 0·160 in., then tapering over 16 in. to 0·050 in. thickness, the remaining length of approximately 11 ft. being of 0·050 in. thick material.

The tube was sectioned to an aerofoil shape, leaving a round portion 9 in. long at the heavy gauge end.

The same principle of combining a minimum of machining with closely-controlled tube drawing was used for a much smaller component used in radar. The specification called for a rectangular section tube 0·9 in. × 0·4 in. i.d. to a tolerance of ±0·002 in.; the wall thickness to be $\frac{1}{4}$ in. of the major axis and $\frac{1}{16}$ in. of the minor axis. One-third of the length of the minor axis was to be reduced to $\frac{1}{16}$ in., leaving the major axis 0·9 in. The tube was to have a tapered thickness from 11 to 21 gauge and inside dimension and tolerance of plus 0·005 in. minus 0·000 in. The surface finish was to be perfectly smooth and free from flaws.

A tubular component to meet this most difficult specification was produced in aluminium alloy and saved half the cost of conventional machining and castings.

A simpler example of tube manipulation methods was the production of a small component of "top hat" shape, in Inconel, for use in jet aircraft. The component had previously been machined from the solid. Forming the component from tube not only gave a large saving on machine time, but also eliminated the waste of much expensive raw material.

Tube drawing and tube manipulation is essentially an economic method of working metal, for it cuts waste to a minimum. The fact that the work is carried out cold also brings other benefits, i.e., improved grain structure and surface finish, and the guarantee that material which has withstood such cold-forming processes is not likely to give trouble with unrevealed flaws when it goes into service.

SPECIAL GLASS WINDOWS FOR HIGH AND LOW TEMPERATURE CONDITIONS

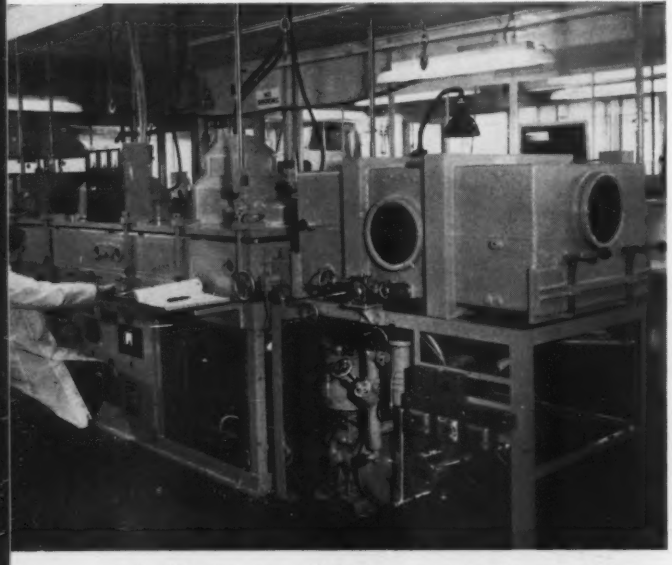
This article describes the types of special glass that have been developed for ice and mist prevention, heat reflection and also for a series of electrical and radio applications

by ALLAN C. WAINE, Ph.D., B.Sc., F.C.S.*

IF mist or ice forms on either surface of a window vision is entirely obstructed and, no matter what care has been taken to use the finest quality glass to avoid distortion and to maintain a high light transmission, these efforts are in vain if all vision has been lost.

In safety glass production many of the most striking advances have been made as a result of the demands of the automobile and aircraft industries, but specialised needs in many other fields have in recent years brought about the development of many new applications. In a number of these, the formation of ice or mist on the glass of observation panels or other windows can cause serious inconvenience or even some danger.

* *Research director, Triplex Safety Glass Co. Ltd.*



In this plant a combined film of gold and metal oxide is deposited on glass electrically in a vacuum chamber. The gold film is two ten-millionths of an inch thick.

Several schemes have been put forward to overcome these difficulties, including the following:

DOUBLE GLAZING UNITS—These are effective in preventing interior mist, but are powerless to deal with external frost. Hermetically-sealed double-glazed units keep the air in the air space dry, but great care must be taken in glazing these so that the sealed edge is not damaged, otherwise mist may collect on the inside surface. They depend upon a warm interior of the vehicle or apparatus and their extra thickness is often unacceptable.

HOT AIR—Hot air may be conveyed by ducts on to the interior surface of the window and is effective in preventing interior mist. The necessary ducting is often complicated and impractical and the amount of heat thus conveyed is usually inadequate to remove external ice.

DE-ICING FLUIDS—These can only be used for a very limited time and are ineffective in the prevention of internal mist. They involve complicated piping and carry a very heavy weight penalty.

ELECTRIC HEATING METHODS—Electrical energy may be used to generate heat; if this heat is distributed uniformly over the window without obstructing vision, an effective method of eliminating both frost and mist is provided.

Two methods of achieving this have been devised by the Triplex Safety Glass Co. Ltd., one by means of a fine grid of resistance wires and the other by a transparent conductive film of gold. Both have proved highly satisfactory and will be considered in more detail.

Electrically-wired Windows

Laminated glass, consisting of two or more pieces of glass tightly adhering to plastic interlayers, provides an ideal medium for the incorporation of an electric heating element. In the case of electrically-wired panels a close-spaced grid of extremely fine wires is embedded in the plastic. These wires are either 0·0008 in. or 0·001 in. in diameter and they are spaced at 40, 60 or 80 wires per inch, depending upon the power input required and the available voltage. Wires of this fineness are practically invisible even when the glass is closely inspected, and when the eye is looking through such a system of wires at a distant object it is entirely unconscious of their presence.

The simplest arrangement is one in which all the wires are electrically in parallel and are connected at either end to tinned copper bus-bars, the latter being brought out to the edge of the panel at any point convenient to the customer (see Fig. 1). If the bus-bars are 9-12 in. apart and a 12-volt current is applied, the resulting power dissipation is 30-36 watts/ft.^{2} Where higher voltages have to be used, or where lower power inputs are adequate, the bus-bars may be split and the wires divided up into a series of banks so that the current must traverse a much longer path. An example of this arrangement is shown in Fig. 2.

In general, an electrically-wired panel has a low resistance of the order of 1 to 10 ohms and this de-misting system is therefore very suitable for motor cars, passenger transport vehicles and aircraft where d.c. voltages of 12 to 28 are normally available.

Where the windows concerned are large, it may be preferable to subdivide the heating grid of wires into a greater number of banks, thus enabling voltages of 110 or 230 to be used directly on a panel (Fig. 3).

Although these extremely fine wires are invisible by daylight, and although they are oxidised to a dark blue colour, nevertheless they tend to diffract point sources of light and this method of electric de-misting is therefore not recommended for the windscreens of motor cars or for the drivers' window of diesel locomotives and electric rolling-stock. The method, however, finds wide application in the rear windows of motor cars and in ships' bridge windows.

The heated area in any given window must be approximately rectangular or parallelogram-shaped, since it is necessary that all the heated wires be of approximately the same length, and thus the bus-bars must be parallel to one another. Triangular and circular windows must consequently contain a rectangular heated area and certain areas of the window therefore remain unheated. It is also necessary that bus-bars must be at least $\frac{1}{2}$ in. in from the edge of the glass, even in a rectangular panel.

The leads which project beyond the margin of the glass may merely be an extension of the bus-bar and consist of a tinned copper strip $\frac{1}{4}$-$\frac{1}{8}$ in. wide and 0·003 in. thick. Wires may be soldered to them and suitably anchored by means of insulating compound inserted into a recess in the glass (Fig. 4) or a simple terminal block may be fitted (Fig. 5). It is preferable, however, that the leads emerge or the terminal block is fitted on one of the vertical sides or the top, so that the condensed moisture does not interfere with the insulation.

Electrically-heated wired panels can be produced in sizes up to 24 in. × 42 in. and in thicknesses from $\frac{1}{4}$ in. upward, depending upon the strength requirements of the application under consideration. Certain curved panels can also be produced with embedded heating wires.

Gold Film Coatings

To overcome the diffraction effects referred to above, to provide a heated window with a higher resistance which can be conveniently run off higher voltage supplies and to provide absolutely uniform heating over a given area, a method of coating glass with a uniform, conductive, transparent gold film has been developed under the name of Triplex G.F.

A combined film of gold and metal oxide is deposited on glass electrically in a vacuum chamber. The gold film is only two ten-millionths of an inch thick, is perfectly clear and exhibits a very pale straw colour which only absorbs 5-8 per cent light. Nevertheless, such a film is capable of carrying up to 1,000 watts/ft.^{2} if sufficient voltage is applied.

The gold film is applied to the inner face of the one glass component so that it is protected from damage and completely insulated in the finished laminated panel.

Fig. 1. Single-bank electrically-wired panel.

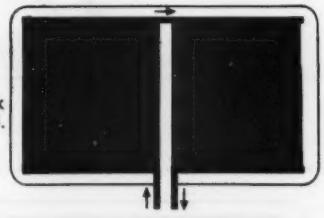


Fig. 2. Double-bank electrically-wired panel.

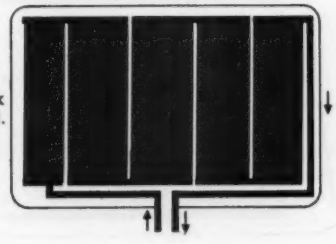


Fig. 3. Multiple-bank electrically-wired panel.

Once again bus-bars are applied to opposite edges of the heated area and, if this area is a square, then the resistance between the bus-bars is 10 ohms and variation in this value is difficult. This value is constant, irrespective of the length of the side of the square.

It is not necessary that the heated area be square, but should preferably be rectangular; slight variations from the rectangular shape may be practicable and the resistance of the finished panel will be dependent upon the dimensions of the heated area (see Fig. 6).

The heated area may also be divided up into banks, thus increasing the resistance of the panel if a high-voltage electric supply combined with a low power input is required. In general, a voltage of 24-240 is necessary for the successful operation of these panels.

The minimum glass thickness to which gold film can be applied is $\frac{1}{12}$ in. and to this must be laminated a second glass component so that the minimum total thickness of such a panel is $\frac{1}{16}$ in. Small-sized panels may be manufactured in $\frac{1}{4}$ in. thickness. The maximum size of flat glass panels to which a gold heating film can be applied is 30 in. × 42 in. Curved panels with a camber not exceeding 1 in. can be produced with a gold heating film.

Main Applications for Gold Film

For heating and de-misting windows, gold film has been found extremely valuable in the aircraft industry, for diesel and electric locomotives, for the bridge windows of Arctic trawlers, as well as for cameras, microscopes and humidity chambers.

A number of other important applications for gold film with glass have been developed, the principal ones being:

HEAT-REFLECTING GLASS—A gold film upon the surface of glass will reflect over 50 per cent of the infra-red radiation falling on it. At a sacrifice of light transmission, this value could be increased to 80 per cent or even 90 per cent reflection. This provides a method of producing heat-reflecting windows for such uses as crane drivers' cabs in steel foundries.

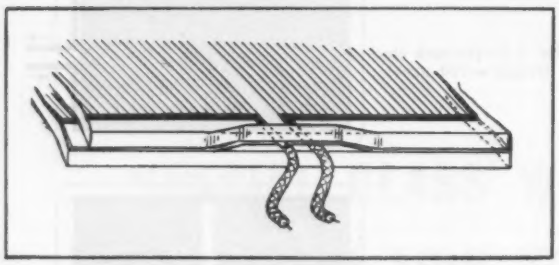


Fig. 4. Flexible wire connection for power leads.

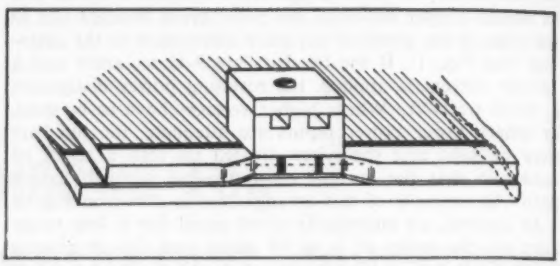


Fig. 5. Terminal block connection for power leads.

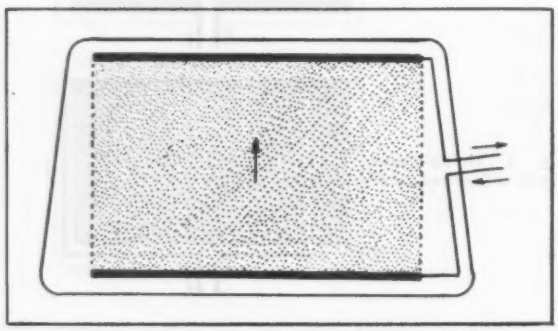


Fig. 6. Simple use of a gold film panel.

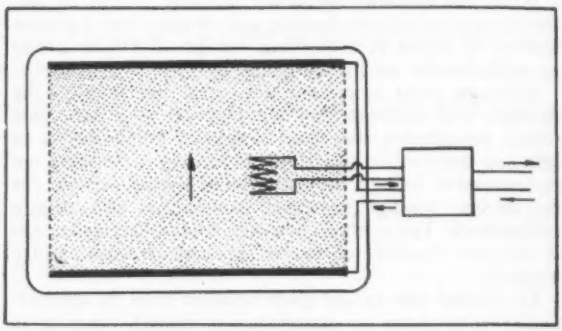


Fig. 7. Gold film panel with sensing element and relay.

RADIO SCREENING—Since gold film is both transparent and conducting, a window in which the gold film is earthed provides a convenient transparent radio frequency screen for applications where it is desirable to observe high-frequency radio apparatus without permitting the escape of high-frequency radiation. In this application, gold film windows appear to be effective up to 1,000 mc/s.

ANTI-STATIC WINDOWS—In any application where it is desirable to prevent the accumulation of static electricity, a gold film on an external surface of the glass will provide a convenient and effective leak to allow for the escape of the accumulated electric charges.

Other applications of particular interest for gold film are its use for transparent electrodes for electro-luminescent lighting devices, transparent radio antennæ and for rendering glass conductive so that other metals can be electro-deposited on it.

Power Requirements

No matter whether embedded wire or gold film is used as a means of electric heating, the power requirements for de-misting or de-icing are comparable.

As a result of experience, the following approximate values for a number of applications are suggested:

Application	*Power input (watts/ft.²)*
In buildings and other stationary positions	20-25
Automobiles and other vehicles, refrigerator windows	30-36
Diesel locomotives, earth-moving machinery, etc.	50-80
Bridge windows for ships	150-250
Pilot's windows in aircraft: de-misting	200-400
de-icing	400-800

Temperature Control

Where the power input exceeds 100 watts/ft.², it is advisable to incorporate a thermostatic control to prevent over-heating of the window. The plastics material used in most laminated glass may bubble if continuously subjected to temperatures in excess of 80 deg. C. and glass may crack at temperatures even lower than this. Control is achieved by embedding a sensing element within the panel in such a way that it is electrically insulated from the main heating element and yet is capable of responding to its temperature changes without any serious lag.

The sensing element usually consists of a length of pure nickel wire of 25 or 100 ohms resistance at 20 deg. C. As temperature rises, so this resistance rises until the small current flowing through the element falls to a value at which a relay controlling the main heating current opens, the current is cut off and overheating prevented.

Under these circumstances a separate external control unit is required and four leads emerge from the panel, two for the main heating current and two for the sensing element (Fig. 7). In certain critical cases a duplicate sensing element is inserted which may be brought into operation should the first element fail.

Where a series of windows have to be heated (e.g., a ship's bridge), one sensing element may be used to control more than one window.

Suitable control units, complying with Admiralty requirements, are manufactured by Wynstruments Ltd. and are available for either a.c. or d.c. and operate direct from the mains voltage. The Plessey Co. Ltd. have also designed and built a range of control units particularly suitable for use in aircraft in conjunction with gold film coatings.

All glass panels that are used to prevent ice or mist formation, or any other special-purpose heated glasses mentioned in this article, are designed specifically to meet the conditions in which they will be used. The designer must therefore provide the glass manufacturer with the following details: (1) the overall size of panel, (2) if curved, drawings giving full details of curvature, (3) area which it is desired to heat, (4) voltage available, (5) power input required, and (6) position of leads or terminal block.

SEMICONDUCTORS – A GROWING INFLUENCE IN DESIGN

The International Transistor Exhibition opens in London at Earls Court on May 21. This article reviews progress in this field and the impact it is making upon the design of engineering products

ELECTRONICS have now become firmly established in all branches of engineering, but the invention of the transistor and other new semiconductors has given a new impetus to the technology of electronics and its development for application to engineering products.

Compared to thermionic valves, which they are to some extent replacing, transistors are very much smaller, more efficient electrically and more robust. Theoretically, they should have an almost infinite life and, although the early examples did not live up to this expectation, improvements in manufacturing techniques have now overcome troubles of surface contamination which were believed to be responsible for this, so that the devices now offered commercially are being accepted as a thoroughly reliable component. Improvements in sealing have also taken place so that variations in performance due to environment are no longer a serious factor.

An indication of the confidence now placed in transistors is shown by the development by Mullard Equipment Ltd. of transistorised reactor safety equipment which is designed to detect abnormal operation in nuclear reactors and to initiate warning or automatic shut-down when a fault signal is received.

The small size of transistorised equipment is not only due to the compactness of the transistor itself, but is also the result of its low power requirements and to a phenomenal advance in miniaturisation of associated components such as resistors, capacitors and plugs. The low power requirements not only permit smaller power supplies to be used but allow components to be mounted very close together without giving rise to overheating. A tremendous advantage over thermionic valves is apparent when transistors are used for portable equipment where the weight of batteries to be carried may be a significant proportion of the whole. For such applications special lightweight miniature batteries have been developed for long life, claimed in some cases to be as long as a year. The use of transistors for applications on aircraft, trains, ships and land vehicles appears to have special importance, because in such circumstances the power supplies are strictly limited. Transistors not only require low power, but also operate at low voltages (6-10 v.), and this allows direct connection from a low-tension source instead of conversion (usually inefficiently carried out) to high-tension d.c.

Before accepting any new material or component, it is most essential to consider not only the advantages but also the limitations so far as these may be known from the limited experience so far gained. Semiconductors are generally far more sensitive to changes in ambient temperature than other electronic components and whilst this property has been put to good use in the development of temperature sensing elements, it may be a serious factor where extreme stability is required. Temperature compensation can be incorporated in many cases, but only at the expense of some increase in circuit complication. Ger-

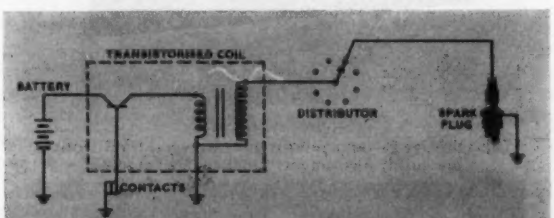
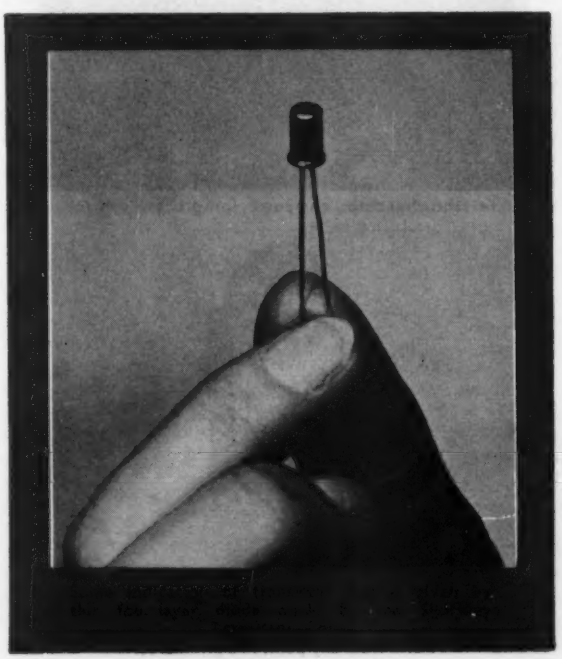
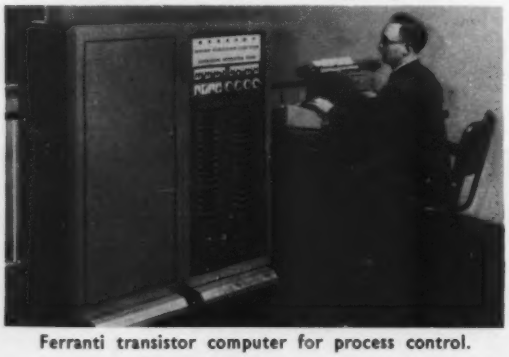


Fig. 1. Ignition circuit for I.C. engine using transistors.



G.E.C. fluorescent fitting with transistor inverter for 24-volt d.c. railway coach supply.

This sensitive galvanometer is one of several transistorised measuring instruments produced by Ferguson.



Ferranti transistor computer for process control.

Multitone electronic truncheon and torch. It can set off an alarm from any point in a given area.

manium devices are usually limited to a maximum temperature of about 75 deg. C., whilst silicon units may be used up to approximately 120 deg. C. These temperatures do not compare favourably with thermionic valves, which may operate up to 200 deg. C. with glass bulbs or as high as 400 deg. C. for ceramic types. At the present stage of development vacuum devices cannot be replaced by semiconductors at high voltages. Similarly, for high power operation it is likely that vacuum valves will continue to show economic advantages for some time to come. In modern equipment a requirement of increasing importance is its behaviour under nuclear radiations, and here again semiconductors have not shown the same resistance as valves, particularly the ceramic type.

Although some interesting and important developments incorporating semi-conductors are mentioned here, it should be realised that these are only a few of the ideas under current development and are not necessarily representative of the whole field. The manufacturing techniques of the semiconductors themselves have made great strides during the last few years, but the full impetus of practical application is only just beginning in this country, and each month brings forth new ideas and designs. In this review the application of transistors to radio and television is not mentioned, as this is a specialist interest.

New Size and Shape

Two main lines of development can be detected in examining the very varied applications of semiconductors to engineering problems: first, to enable substantial size and weight reductions to be made in portable or transportable equipment and second, to make possible new designs which were uneconomical or impracticable by orthodox techniques. An example of the former is a series of portable battery-operated equipment by Dawe Instruments Ltd., who have developed transistorised instruments such as the Type 1211 stroboscope and 1400 E sound level meter. The latter weighs only 3½ lb. compared to about 15 lb. for the valve model, but further advantages are claimed in respect of battery life and absence of microphony.

In the field of computers, which are increasingly used for engineering design and calculations, the use of transistors has resulted in greatly improved life and reliability so that their use has reduced equipment errors due to ageing and failure of valves. Design of computers involves the positioning of very large numbers of units and the high efficiency of transistors not only reduces the amount of power required to operate the equipment but also greatly assists in solving the problems of cooling and ventilation. In combination with printed circuits, transistors give enormous size and weight reductions; both Ferranti Ltd. and Metropolitan Vickers offer such equipments. These developments are of interest for automatic machine tool control where the use of transistors for computers and associated equipment offer greater reliability and simple maintenance. Such units are being considered for the automatic control of boilers during start-up and shut-down.

The General Electric Co. and C.A.V. Ltd. have developed special converter units for supplying fluorescent lamps from low-voltage d.c. sources such as batteries. Fluorescent lamps, although more efficient than incandescent ones, can be operated at even higher efficiency by the use of higher frequency supplies, compared to the 50 c/s mains supply normally used. The use of fluorescent lighting on trains, aircraft and land vehicles is restricted by the absence of a suitable high-voltage supply and hitherto such installations have included rotary generators for converting the low battery voltage to high-voltage a.c. These generators are heavy, bulky and inefficient, but

Multitone staff location system providing thirty-six separate channels.

Transistor techniques have enabled the size of this Sperry chronometer to be kept to a minimum.

transistors now offer a solution by providing a practicable converter operating off the low-voltage battery supply, as well as producing a high-frequency output for a higher efficiency.

Transistor units are being developed for I.C.E. ignition systems and it is forecast that within two years these will be available for motor-car engines. Fig. 1 shows the theoretical layout where a transistor is used as a switch to carry the heavy primary current of the coil and it is controlled by a light current by the contacts on the distributor. As the contacts only handle a very small non-inductive current, no condenser is necessary, thereby eliminating a common source of engine failure. The greatest advantages of this system are realised with high-compression engines which are being designed by the motor industry to meet the demand for higher performance cars and commercial vehicles. Conventional coil ignition has been known to fail in cold weather, when used at high speeds and after prolonged use. Magnetos perform well at high speeds but, besides being expensive, do not make for easy starting as they do not generate sufficient voltage at low speeds. The transistor-controlled unit is claimed to give a constant output at all speeds and to require the minimum of maintenance over very long periods of service.

A new range of electrical measuring instruments has recently been announced by Ferguson Radio Corp. Ltd., including a null indicator and a thermocouple-type temperature gauge, both based on a transistorised amplifier which combines low noise and drift characteristics. These instruments combine a robust meter movement with a full-scale sensitivity of 100 millimicroamperes at 1 mV. and a useful practical feature is that the overload capacity is 100 times full-scale input, which is much higher than that of any normal galvanometer movement. The instruments are powered by an internal battery which is permanently connected to the amplifier, no on-off switch being provided, and in this way warm-up drift is eliminated. Battery life is said to be about six months under these conditions.

Replaces Blueprints

A new method of instructing workers which is claimed to increase production rates by from 20-100 per cent is being investigated by the Dictaphone Co. Ltd. This system, called AIMO (Audio Instructed Manufacturing Operation), is intended to replace the normal instructions given by blueprint or written document. It is operated by a tiny receiver about the size of a cigarette lighter attached to the belt of the worker whose freedom of movement is unaffected by the apparatus. The receiver picks up instructions fed by a modified play-back machine from tape, the mechanism being controlled by the worker who steps on hydraulic tubes laid in the floor to start or replay a given block of instructions. The system has been successfully used in America for operations such as wiring up intricate circuits and the same set of instructions can be used by a group of workers irrespective of their rate of work.

An application of transistors where light weight, portability and low battery consumption is important is the contamination monitor BN. 116 developed by Burndept Ltd. Designed for selective detection and measurement of different types of radiation, the equipment may also be used as a highly sensitive geological survey instrument. The instrument weighs 5½ lb. and is powered by two U2 cells which are said to provide over 100 hours of operation before requiring replacement.

Solar Converters

Solar converters are now available for converting the radiant energy from the sun or from incandescent lamps into electrical energy. They have a response time of a few microseconds and operate without deterioration under conditions of high humidity and temperature. Based on silicon, multi-element units are available from Ferranti Ltd. and these have been used in connection with electronic data-reading systems. The conversion efficiency of silicon solar cells is the highest known and is said to exceed 10 per cent. This means that from each square yard of converter exposed to sunshine, a power output of about 100 watts is possible. Many practical applications for solar cells are being considered for remote equipment which can be powered by batteries automatically recharged from the sun's radiation. Examples are navigational aids at sea, obstacle marking on land or sea and telephone relay stations. Domestic products such as flashlights, tape-recorders and clocks are also possible applications.

Silicon rectifiers for high power circuits such as electric rail traction and electro-chemical factories provide an efficient and robust means of converting a.c. to d.c. and offer several advantages over mechanical and mercury-arc rectifiers, in particular low maintenance, high conversion efficiency and long life. Compared to germanium power rectifiers which were first used, the silicon units may be operated at much higher temperatures (junction temperatures of 200 deg. C. have been claimed in the U.S.A.) and they have inherently higher voltage ratings. The silicon rectifier is expected to be almost dominant in the applications below 600 volts for electro-chemical works, switchgear, battery chargers, and control and metering equipment.

designer's notebook

Linear Constant-temperature Hot-film Anemometer

THE problem of how to measure and record mean and turbulent velocity components of gas or water, particularly when they are as high as those encountered in jet engines, has always been a formidable one. Although the hot-wire anemometer has long been used, it is a fragile instrument with a short life.

The solution appears to have been developed by Lintronic Ltd., who have been working on a constant-temperature hot-film anemometer. The instrument has been found satisfactory for measuring mean and turbulent velocity components of gas or water with temperatures of 500 deg. C. and 50 deg. C. respectively.

The sensing element, a small glass rod with the wedge-shaped end coated with very thin platinum, is mounted in the flow medium and connected through a cable. It is rugged in comparison to conventional hot-wire elements and has stable physical characteristics over long working periods, excellent dynamic response ($-\frac{1}{2}$ dB. for 10-100 kc/s. at 1,000 ft./sec. mean velocity) and high signal-to-noise ratio.

The platinum film is heated to a predetermined temperature and when gas or water flows over it the film is cooled, but the temperature is kept constant by an electronic feedback system. This increase in heating current gives a measure of the velocity over the film.

The sensing element can be of a variety of geometrical forms depending on the nature of the application. Standard probes include:

30 deg. wedge axial type
45 deg. wedge axial type
30 deg. wedge axe type for radial insertion
Conic and spherical types

The instrument was designed to investigate microscale turbulent flow characteristics along a boat hull, but has since been used for measuring and recording various types of complex flow as would be encountered in gas/steam turbine, jet exhaust, boundary layer studies, paper pulp flow, etc.

The heated film, which measures only 1·0 × 0·2 mm., is supplied by 110-125/220-250 volts, 50/60 c/s, regulated to less than 100 microvolt hum level against load changes and line surges. Output terminals are provided for both mean and turbulent flow recording on tape or cathode-ray oscilloscope.

The velocity range which the instrument is capable of covering is 5-1,500 ft./sec. in gas, 1-60 ft./sec. in liquid (read directly from d.c. milliammeter).

Seal Failure Warning Device

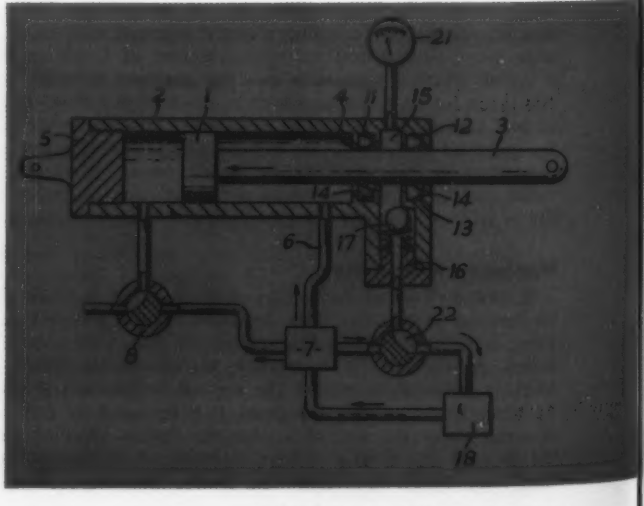
IN our March issue we gave examples of ideas for safety devices which provide warning of mechanical failures.

A recent patent granted to the Sperry Gyroscope Co. Ltd. provides an excellent example of such a device. The invention relates to a sealing arrangement for a shaft which is longitudinally movable in an aperture in the wall of a pressure fluid chamber; for example, the shaft of a hydraulic jack which passes through an end wall of the cylinder. Should fluid be able to leak across such a seal, not only will the fluid in the system be eventually lost, but there may be a danger of fire due to the presence of the escaped oil. The object of the invention is to provide a sealing arrangement rendering the possibility of either occurrence less likely.

The sectional diagram shows one possible embodiment of the invention. A conventional hydraulic servo, consisting of a piston (1) sliding in a cylinder (2), has a piston rod or shaft (3) extending through the end wall (4) of the cylinder. The invention is concerned with the method of sealing the shaft (3) in the end wall in order to render loss of fluid from the system unlikely. To achieve this, the shaft (3) is sealed in the wall (4) with duplicate seals, (11) and (12), which are of the conventional lip-type gland seal consisting of a U-section ring (13) in an annular groove (14) formed in the wall (4). Between these seals is a space (15) for any fluid which may leak from the cylinder (2) past the inner seal (11). The leakage space (15) communicates through an aperture (16), controlled by a spring-loaded ball valve (17) with the pressure fluid sump (18).

Normally, the leakage fluid is not at sufficient pressure to close the ball valve and can run freely to the sump. But if seal (11) should fail, so that fluid pressure builds up in the leakage space, the pressure could become great enough to close the ball valve against its spring, and this state of affairs could be indicated on a pressure gauge (21).

Although an unlikely occurrence, the outer seal could fail first. To provide for this possibility, it could be arranged that routine tests of this seal were made from time to time. For example, by manipulating a cock (22) to close the outlet of the valve (17) from the sump (18) and to connect it to the source of pressure fluid (7) so that fluid pressure will build up in the space (15). If the seal is intact, the gauge (21) will give a reading, and no fluid will appear at the outer side of the wall (4). If, however, the seal is faulty, a drop in pressure on the gauge and external leakage will provide evidence of this.

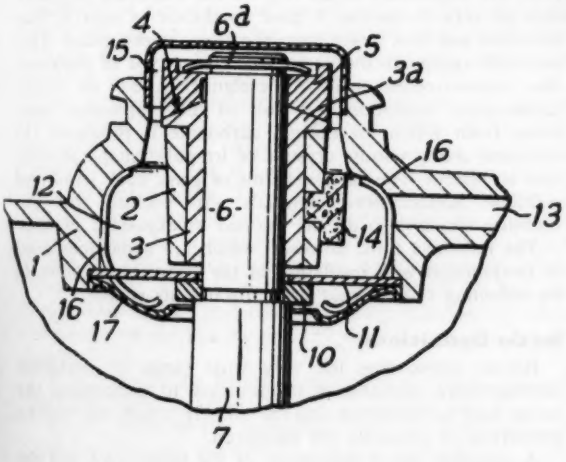


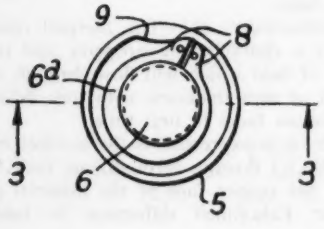
New Bearing Developments for Electric Motors

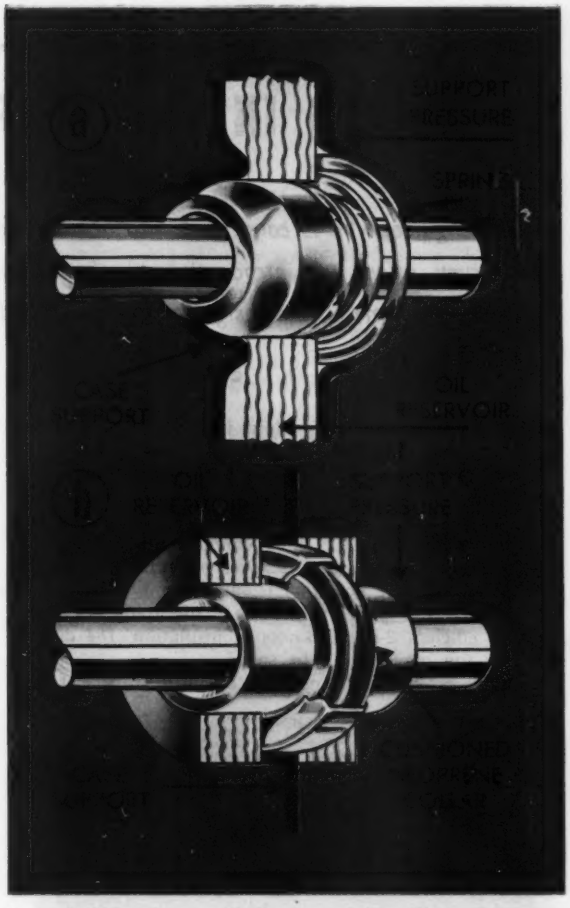
TWO new designs for plain bearings of the self-lubricated type have recently appeared, one of which is British and the other American. The bearing illustrated in the sectional views below has been designed and patented by Newman Industries Ltd. to provide a simple bearing assembly for vertically mounted motors, having adequately lubricated end thrust surfaces. Integral with the casework of the motor (1) is a tubular portion (2) bored to receive a porous iron bush or bearing (3) having a shoulder (3a) which abuts against the upper end of the tubular portion (2). The upper surface of this porous iron bush is formed with a part-spherical or convex surface which is engaged by the concave surface of a porous bronze bearing or thrust washer (5) which is mounted on the outer end of the journal (6) of the shaft (7). Rotation of this washer is effected by the projecting lugs of a circlip on the shaft which engage an inwardly directed cam-shaped projection (9) on the washer. One or other of the two lugs will engage this projection according to the direction of rotation.

An inner washer (10), of moulded nylon material, is provided at the inner end of the journal (6) and simply constitutes a means of location. It engages a spring washer (11) to give resilience laterally. The annular space (12) between the tubular part (2) of the housing (1) and the outer wall is preferably wool-packed and constitutes a sump for oil, being replenished through an oil inlet (13). Oil from the sump is fed to the prelubricated porous iron bearing bush (3) by means of a felt contact pad (14). This oil is exuded from the bearing not only to the surface of the journal, but also to the thrust washer which, in turn, absorbs the lubricant but also throws it out centrifugally through its side pores into the well (15) of the housing, whence it passes through drain holes into the main sump (12).

Lubricant which is thrown from the bottom of the journal (6) by the moulded nylon washer (10) is picked up by two felt wicks (16) which dip into an inner bearing cap (17) and return oil to the main sump.







The second self-lubricated bearing, recently developed by Universal Electric Co., does away with the conventional compression spring for maintaining the alignment of such bearings in a concave bearing recess (see (a) above).

In the new bearing, (b), support pressure is exerted by a pre-compressed neoprene collar which, constrained by four metal clips, is fitted to the centre of the bearing and so provides support at the centre of the bearing. Not only does the neoprene collar accommodate manufacturing tolerances, expanding or contracting within the clips to form a fit between the bearing and bearing support faces, but it serves also to accommodate a certain amount of misalignment.

CONTRIBUTIONS INVITED

Readers are invited to submit for publication in "Designer's Notebook" details of ingenious devices and mechanisms which could be used more widely than in their original application.

Contributions, which will be paid for, should preferably be about 300 words in length and be accompanied by an explanatory diagram or sketch. The designer's name will be published, unless requested otherwise.

Contributions should be sent to The Editor, "Engineering Materials & Design", Drury House, Russell Street, London, W.C.2.

SELECTION OF THERMAL INSULATION MATERIALS IN ENGINEERING

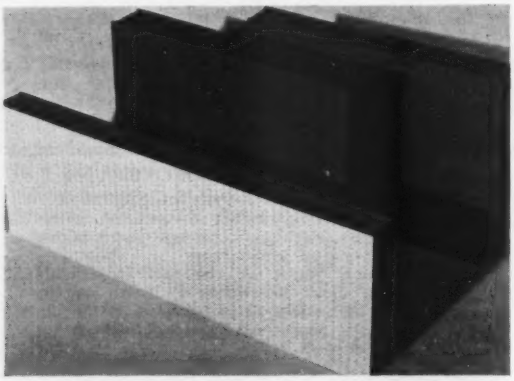
For the engineer who is concerned with heat insulation problems, this survey offers an introduction to the types of materials available and some of the design factors and calculations involved

GOOD insulation in modern industry is a necessity. For this fact to be brought home forcibly, an examination of specific instances of the cost of no insulation or poor insulation provides abundant evidence. Two practical examples will serve to illustrate this:

1. A 4-in. bore pipe 1 ft. long, carrying steam at 500 deg. F. in its uninsulated state, requires one ton of coal in a year to provide the heat that is subsequently lost through its walls to atmosphere. If this 1 ft. of piping is covered with an efficient 2-in. thickness of insulation, 18¾ cwt. of this one ton of coal will be saved.

2. If the crown of a Lancashire boiler 30 ft. × 8 ft. dia., producing steam at 350 deg. F. is uninsulated, 105 tons of solid fuel will be wasted annually due to loss of heat through the crown. Covering the crown area with an efficient 2-in. layer of insulation reduces the loss from 105 tons to 6 tons per annum.

A good example of sectional cork applied to a pressure vessel before covering. (Photo: Dicks Asbestos & Insulating Ltd.)



Insulating panel, employing sandwich of foamed phenolic resin core faced with decorative laminated sheet. (Photo: Bakelite Ltd.)

In Table 1 the heat losses from uninsulated horizontal steam pipes are indicated for various bores and temperatures of surface.

Although recommended thicknesses of various types of insulation to British Standard for steam pipes are provided by the insulation suppliers, and efficiencies of insulation ranging from 75-95 per cent are achieved, it is important that the user should understand the principles of insulation and be able to carry out a few simple calculations. Not only must he be able to estimate the kind of insulation required, but also he should be able to calculate its thickness.

Almost all thermal insulation, apart from the reflecting foils, are substances which rely on the enclosure of many tiny air cells or spaces. A poor conductor of heat is thus provided and heat losses by convection are prevented. This principle applies to the corrugated paper type of material, the diatomaceous clays (kieselguhr) used in high-temperature insulation and also in the magnesian limestone from which magnesium carbonate is produced. In this case, many minute crystals of irregular shape provide tiny air spaces. The various forms of glass, rock wool and cellulose acetate fibre materials also enclose and immobilise air, as also do the foamed or expanded plastics.

The reflective foils, however, which are sometimes used in conjunction with insulation of the above types, operate by reflecting radiant heat back towards its source.

Basic Definitions

Before considering the very wide range of materials commercially available, it is necessary to understand the terms used in insulation and the units in which the various properties of insulants are measured.

A complete list of definitions of the terms used and the methods employed for determining thermal conductivity are given in B.S. 874:1956. However, the basic definitions are those given here:

THERMAL CONDUCTIVITY (k)—The thermal conductivity of a material is a characteristic property and is defined as the quantity of heat which will flow through unit area of that material of unit thickness with unit difference in temperature between faces in unit time.

In British units it is expressed as the number of British thermal units (B.t.u.) flowing through one inch thickness of the material per square foot of the material per hour per one degree Fahrenheit difference in temperature

between the faces (B.t.u. in./ft.² h. deg. F.).

THERMAL CONDUCTANCE (c)—This factor is defined as the thermal transmission per unit area divided by the temperature difference between the hot and cold faces. In British units it is expressed as the number of British thermal units transmitted in one hour through one square foot of material or materials of any given thickness for a difference in temperature of 1 deg. F. (B.t.u./ft.² h. deg. F.).

THERMAL RESISTANCE (r)—This is the reciprocal of thermal conductance. This unit is useful in that the resistances of a number of components of an insulating structure can be added together, the total thus obtained being the resistance of the compound structure.

THERMAL TRANSMITTANCE OR "U" VALUE—The thermal transmittance is the thermal transmission through unit area of a given structure divided by the temperature difference between the air or other fluid on either side of the structure. In British units it is expressed as the number of British thermal units flowing through one square foot in one hour per one degree, Fahrenheit difference in temperature (between the inside and outside air) (B.t.u. /ft.² h. deg. F.).

Thermal transmittance is not a characteristic of the structure alone, but varies according to the prevailing conditions of convection and radiation, and can be affected by wind, sun, rain, etc.

Although for certain applications the highest possible efficiency of insulation is of paramount importance, regardless of cost (e.g., calorimetric or other special plant or apparatus), the cost of insulation for general plant use limits the thickness that can be employed. Since the total number of working hours per annum varies widely between different insulations, calculation on a theoretically economic basis is extremely difficult. In the insulating industry it has been the custom to base calculations on a financial depreciation time of five years.

B.S. 1588:1949 (Thermal Insulating Materials Suitable for Use within the Temperature Range 200-450 deg. F.) provides useful guidance on how to calculate the correct thickness of two classes of insulations, as well as providing tables giving actual thicknesses recommended for the two classes. Class A thickness is for continuous usage, and Class B is for intermittent usage.

For the tables provided in this Standard, calculations were based on the assumed repayment times of five years at 8,000 hr. per year (40,000 hr.) and five years at 4,000 hr. per year (20,000 hr.), the cost of heat being assumed to be 4d. per useful therm. The insulation charges were average commercial costs for reputable insulating material applied and finished in a normal way. Other British Standards which provide useful information on thickness of insulation are B.S. 1304:1946 and B.S. 1334:1947 for hot and cold water supply and central heating installations where temperatures do not exceed 180 deg. F. and 220 deg. F. respectively.

In a forthcoming British Standard at present in preparation, the range is from 400 deg. F. to 800 deg. F.

Useful formulæ for calculating heat loss from insulated surfaces (flat and cylindrical) are given below:

Insulated Flat Surfaces

$$(1) \qquad q = \frac{ts_1 - tm}{\frac{L}{k} + \frac{1}{f}}$$

$$(2) \qquad ts_2 = \frac{\frac{L}{k}(tm) + \frac{1}{f}(ts_1)}{\frac{L}{k} + \frac{1}{f}}$$

Insulated Cylindrical Surfaces

$$(3) \qquad q = \frac{ts_1 - tm}{\frac{A}{k} + \frac{B}{f}}$$

$$(4) \qquad ts_2 = \frac{\frac{A}{k}(tm) + \frac{B}{f}(ts_1)}{\frac{A}{k} + \frac{B}{f}}$$

q = (1) heat loss per square foot of flat surface, B.t.u./hr. (3) heat loss per lineal foot of cylinder, B.t.u./hr.

ts_1 = hot face temperature of insulation, °F.

ts_2 = cold face temperature of insulation, °F.

tm = ambient temperature, °F.

L = thickness of insulation, in.

k = thermal conductivity at mean face temperature, i.e., $\frac{ts_1 + ts_2}{2}$, (B.t.u./hr./ft.²/in./°F.).

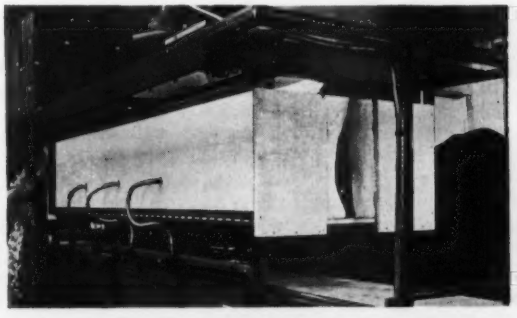
f = surface coefficient, B.t.u./hr./ft.²/°F.

$$A = \frac{12}{2\pi} \log_e (d_1/d_2)$$

$$B = \frac{2 \times 12}{2\pi d_1}$$

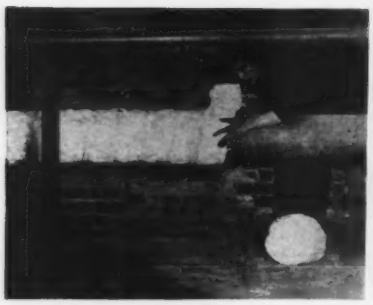
where d_1 = outside diameter of insulation, in.
d_2 = outside diameter of cylinder, in.

The calculation procedure using these formulæ is as follows:



Building and insulating an electrically-heated conveyor drying oven in one operation with ½-in. Marinite 36. (Photo: Cape Asbestos Co.)

Rocksil rockwool insulation was used as insulation at the experimental atomic power station at Dounreay in Scotland.



Insulating a pipe by bandaging with Fibreglass strip.

Amosite asbestos moulded pipe section sawn at Cape Asbestos works.

Application over cork insulation of Denso Therm tape to exclude moisture.

Required information: q
ts_2

Known information: ts_1
tm
k (over a range of mean face temperatures as provided by manufacturer)
d_1, d_2 } values of A and B for various combinations of d_1 and d_2.
L

Assumed information: f (recommended values of f).

Steps:
(i) Assume a value of ts_2.
(ii) Based on the above value of ts_2 estimate k (from manufacturers' catalogue).
(iii) Calculate ts_2 from formula (2) or (4) above.
(iv) Continue by progressive trial and error calculations ((i), (ii) and (iii) above) until assumed value of ts_2 equals calculated value.
(v) Calculate q from formulæ (1) and (2), inserting the value of k at $\frac{ts_1 + ts_2}{2}$.
(ts_2 determined in (iv) above.)

Accuracy and limitations: The estimates of heat loss and cold face temperature based on the formulæ above and the suggested values of f are as accurate as can be justified, bearing in mind the order of error on thickness of insulation applied in practice and normal variations in quality of insulation materials. Estimates so calculated are realistic and assume indoor conditions without draughts.

If it is anticipated that heat loss figures are critical and if indoor conditions are draughty or outdoor conditions windy it is recommended that a safety factor be applied.

An interesting graphical method by McMillan[1] enables various thicknesses of insulation to be related to per cent fixed costs. It consists of a family of graphs, so juxtaposed that it is possible to arrive at the per cent fixed charges that a given thickness of insulation represents.

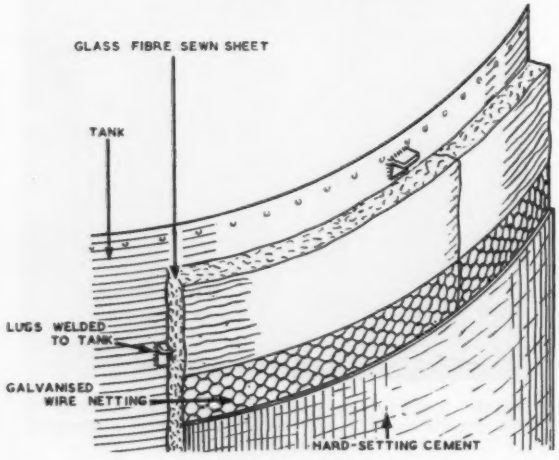
The following factors must be known:

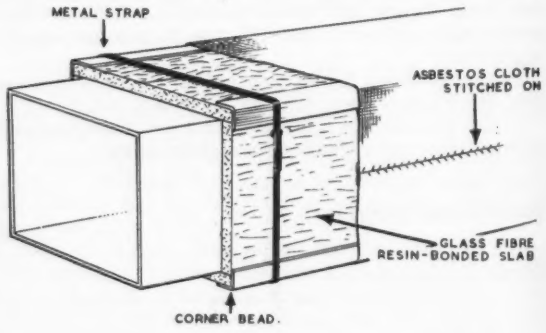
1. Number of hours of operation per year.
2. Cost of heat per 1,000,000 B.t.u.
3. Temperature difference between pipe and surrounding air.
4. Value of thermal conductivity of insulation.
5. Cost of insulation per board foot.
6. Rate of amortisation per cent per year.

Materials Available

Engineering insulation falls into the following main categories: (1) hot surfaces, (2) cold surfaces, (3) insulation materials to guard against condensation, and (4) special-purpose insulation, e.g., furnace brick linings, insulating concrete and specialities. Table 2 lists the main types of materials available.

Moulded sections can now be obtained to suit almost all pipe layouts in sizes up to 15 in. diameter, and these are usually available in thicknesses up to 4 in. in ½-in. increments. The sections are usually sufficiently robust to stand normal handling and transport and are easily ap-





Above. Fibreglass resin-bonded slab fitted on rectangular duct.

Left. Insulation of cylindrical tank or duct (indoors) using Fibreglass.

plied with the straps and clips provided. Similar materials are also available in block and slab form.

The bandage type is rapidly gaining popularity due to its ease of application, particularly where pipes have access all round and the bandage roll can be readily applied.

The quilt or mattress finds favour for large-diameter pipes or tanks, while for smaller-diameter pipes string and rope are still much in favour owing to their ease of application and ability to shape readily and give a neat finish. Fibrous asbestos and diatomaceous earth compositions are also available for sealing pre-formed and slab insulations.

Sprayed asbestos enables large areas and irregular surfaces to be covered.

The foamed materials are excellent insulants for refrigeration, particularly for low-cost panelling in block and slab form which can be easily provided. By the reaction together of suitable chemicals so that carbon dioxide is released, it is now possible with suitable equipment to produce rigid urethane foams which can be produced *in situ*. Some of these foams have a measure of structural strength and so can reduce the weight of insulation in refrigerated ships and provide a measure of protection for the underlying metalwork. A recent process developed by I.C.I. Ltd. enables a layer of foam to be applied by spray, ¼-in. thickness being applied at the rate of 24 sq. ft. per minute.

Although most of the foamed materials are only suitable for cool or cold work, and will melt at the lower steam temperature range, an interesting recent development by Bakelite Ltd. is a foamed phenolic resin. Being rigid, the material can be used not only as an insulant but, in the heavier grade (4-4½ lb./cu. ft.), it can function also as a structural material, particularly when used as the honeycomb core of a sandwich material. It can be produced in slab, pre-formed shapes, and it can also be foamed *in situ*. It can withstand continuous subjection to temperatures up to 300 deg. F., and for short periods can be used at temperatures as high as 400 deg. F. It is self-extinguishing.

For very low-temperature insulation cellular glass is available in which bubbles of air or gas are enclosed. This is much favoured in America. A foamed glass now available in this country is claimed to be suitable for temperatures up to 800 deg. F. Available in block and slab form, it is suitable for the insulation of floors and ceilings, being fixed in position with molten asphalt or tar emulsion. It is extremely light, can be cut with a sharp knife or saw and is impervious to vapours, gases and water. It should, however, be protected from mechanical damage.

Cork slab, a traditional cold insulator, when applied with a bituminous or rubber type of adhesive and skimmed up externally with a vapour barrier, provides one of the best insulators for refrigerated surfaces.

Insulating foils have also recently become more evident, particularly in the low-temperature range.

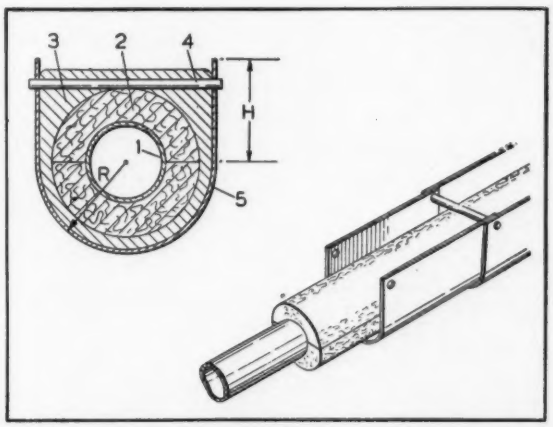
Condensation and Water Absorption

The effect of water absorption can drastically affect the insulation properties of a material. This was convincingly demonstrated by the London Brick Co. in a recently-conducted series of tests on various types of wall constructions. It was shown that the insulating property of a cellulose concrete inner wall was reduced from a theoretical "U" value of 0·18 to 0·22. Damp insulation may take a considerable time to dry out.

The condensation problem usually met in industry is where water vapour in the air is being constantly replenished, as in laundries, mills, baths, dye-houses, etc. When this water-laden air comes into contact with surfaces below the dew-point of air, a constant formation of water will be present on the cooled surface.

TABLE I. Heat losses (B.t.u./lin. ft./hr.) from uninsulated horizontal steel pipes calculated for still ambient air at 68 deg. F.

Pipe Size		Pipe Temperature, °F.				
Bore in.	o.d. in.	100	200	300	400	500
¼	⅜	13	85	178	298	451
¾	1 1/16	16	104	218	369	554
1	1 5/16	20	127	269	452	679
1½	1 11/16	27	172	364	619	933
2	2⅜	33	208	441	752	1,138
2½	3	41	256	547	929	1,417
3	3½	48	293	628	1,067	1,631
4	4½	60	370	790	1,343	2,062
5	5½	72	446	950	1,613	2,491
6	6½	85	529	1,128	1,918	2,967
8	8⅝	106	666	1,423	2,461	3,793
10	10¾	129	816	1,745	3,039	4,672
12	12¾	154	968	2,070	3,572	5,525



Stillite systems of underground pipe insulation: 1. Pipe. 2. Stilag insulation. 3. Bitumen. 4. Corrosion-proof rod. 5. U-trough.

The most obvious way to deal with this problem is to raise the temperature of the surfaces above the dew-point of the air. This can be done by many different insulation methods.

Sprayed asbestos is highly efficient in this respect in that it excludes all air spaces and stops the water-logging effect. Being fibrous, it will absorb moisture and, when conditions become more normal, will readily give up the moisture, leaving the coating unaffected.

The expense involved in providing adequate insulation can be considerable. Sometimes, however, ingenuity on the part of a plant engineer can save money.

An example is provided by one plant engineer who was confronted with the problem of running an underground insulated pipe between two buildings. To avoid the cost of excavating a channel 12 in. wide and lining it with bricks, he surrounded the pipe, which was insulated with a cheaper form of inside insulation, with channel sections of galvanised steel sheet, the space between the insulation on the channels being filled with tarmac and bituminous road surface topping. Bitumen compound was poured over the surface to prevent the ingress of water.

A similar principle is illustrated on this page.

ACKNOWLEDGMENTS

We acknowledge with thanks the valuable assistance given with this article by H. Daniel Hall, A.M.I.Mech.E., A.M.C.T. (Hall & Kay Ltd.). Also to Bell's Asbestos & Engineering Ltd. for the heat loss calculation procedure given on pages 325 and 326.

1. McMillan. *Trans. A.S.M.E., Fuels Steam Power*, **51**, 349 (1929).

TABLE 2. Principal types of insulating material for engineering applications

Type	Forms Available	Physical Properties			Suitable for Temp. Range	Principal Applications	Remarks
		K Factor	Density lb./ft.^{3}	Water Absorption			
Fibrous asbestos	Pipe and block. Can be applied in spray form.	0·37 at 200 deg. F.	12–14	Soaks up water but dries readily	With diatomaceous earth up to 1,200 deg. F.	Prefabricated fittings, bridging flanges and flange valves, and where above-average strength is required.	Can be removed and replaced many times. Rugged and durable.
Calcium silicate	Pipe and block. Manufactured by both extruded and moulded processes.	Approx. 0·35 at 200 deg. F.	12	Absorbs water but dries.	Up to 1,200 deg. F.	Prefabricated fittings.	Will not resist impact, although reasonably strong.
Fibrous glass	Prefabricated section	0·28 at 200 deg. F.	6	Does not absorb water.	Up to 400 deg. F.	All pipework.	Tends to be irritant; protective clothing necessary when applying.
Fine spun glass	As fibrous glass, but also in bandage and quilt for quick application.	0·25 at 200 deg. F.	5	Does not absorb moisture.	Up to 400 deg. F.	Largely in "void" fillings and lay-on types of coverings for blanketing. Refrigeration with moisture seal.	ditto.
85% Magnesia	Pipe and block. Can be applied soft in composition form.	0·38–0·45 at 200 deg. F.	12	Absorbs moisture.	Up to 550 deg. F.	Boiler and pipe coverings where water attack not expected.	Lacks strength; must not be subjected to rough usage.
Mineral wool	Rigid block, blanket and cements.	0·35 at 200 deg. F.	Wide variation	Fair resistance to water	1,200–1,500 deg. F.	Very wide range of insulations subject to recommendation of suppliers.	In blanket form, it tends to "settle". Easy to apply. Block tends to be fragile.
Cellular glass	Flat block and sections.	0·38 at 50 deg. F.	9	Does not absorb completely. Vapour proof.	— 350 deg. F. to 700 deg. F.	Low-temperature work but can be used on heat.	Subject to breakage due to shock. Very rigid.
Vegetable cork	Block and sections.	0·28 at 50 deg. F.	8	Does not absorb water.	300 deg. F. downwards	Refrigeration work—must have vapour seal.	Easy to cut.
Expanded polystyrene	Soft block and sections.	0·2 at 50 deg. F.	1½lb./ft.^{3}	Good resistance to water.	150 deg. F. downwards	Refrigeration work and low-temperature applications. sandwich form.	Most easy to apply, but needs complete protection due to soft, fragile nature.
Foamed phenol-formaldehyde	Block and slab or or foamed *in situ*.	0·28 at 50 deg. F.	1 (light-weight) 4–4½ (structural)	Good resistance to water.	300 deg. F. downwards	For low and medium temperatures. Structural uses in sandwich form	Self-extinguishing

Principal Manufacturers and their Ranges of Insulation Materials

It should be noted that the information given below is intended for general guidance only and does not claim to be exhaustive.

Alfol Insulation Ltd.
Aluminium foils for high and low temperatures.

D. Anderson & Son Ltd.
Outer wrap for pipelines made from glass fibre impregnated with saturants, for use with asphaltic bitumen and coal tar enamels. Also armour wraps.

Ardor Insulation Co. Ltd.
Corrugated aluminium foil in rolls, mainly for buildings.

Bakelite Ltd.
Phenol-formaldehyde foam in rigid sheet (light and heavyweight grades). This foam can be produced *in situ*.

Baxenden Chemical Co.
Foamed polystyrene products.

Beldam Asbestos Co. Ltd.
Asbestos fibre pre-forms and slabs for hot and cold water, low- and high-pressure steam.

Bell's Asbestos & Engineering Ltd.
Pre-formed sections, round and pear-shaped (for tracing lines) and also panels, in cellular corrugated asbestos paper interleaved with aluminium foil. Temperature limit 650 deg. F. Range of insulating felts in various densities. Rigid asbestos sheets and pre-formed pipe sections and flexible sheets (1,000 deg. F. for rigid sheets, 800 deg. F. for flexible). Mattresses (in rigid or flexible form) for up to 850 deg. F. 85 per cent magnesia in pre-forms and slab for 400 deg. F. Inorganic micro-porous materials bonded with high-temperature resistant asbestos fibre for up to 1,625 deg. F. (in powder form for plastic application and also in pre-formed sections, lags and slabs).

British Celanese Ltd.
Cellulose acetate fibre in rolls for building insulation. The fibre is in a sandwich of aluminium foil.

B.X. Plastics Ltd.
Corrugated lightweight sheets of cellulose acetate film assembled in layers for walls, ceilings and vehicles. Expanded polystyrene.

Bury Felt Mfg. Co. Ltd.
Compressed-felt insulating materials.

British Refrasil Co. Ltd.
Flexible equivalent of solid fused silica, batt, cloth, tape, bulk fibre, sleeving, cordage and yarn. Glass fibre for jet engines and other applications.

Celotex Ltd.
Flame-resistant and other insulation boards for walls and roofs.

Cape Building Products Ltd.
Asbestos tape, cloth yarn and rovings.
Silica asbestos boards for building insulation.
Long-fibred rock wool from which are made slabs of light, medium and heavy duty, 1-4 in. thick, for temperatures up to 600 deg. F. Mattresses with galvanised wire netting on both sides. Rigid pipe sections for refrigeration and frost protection for cold water piping, heat conservation on hot water lines, steam and traced oil-lines for temperatures up to 600 deg. F. Flexible sections with wire on one side. Scrim-backed sections. Sewn sheet, sewn strip and felted mat for easy-to-fit applications. Lightly bonded mat, batt and loose rock wool for industrial ovens and other equipment.
Pressed asbestos in sheet form for cabinets, ovens, etc., up to 900 deg. F.

Cape Asbestos Co. Ltd.
Asbestos fibre pipe covering and slabs, for inside and outside use. Asbestos and hair felt pipe coverings for steam. Cork insulating slabs and pipe coverings for brine and ammonia. Magnesia and asbestos slabs and pipe coverings. Compressed sectional pipe coverings for cold water. Asbestos rope and lagging. Asbestos mattresses and insulating jackets. Antithermic cement and bricks for furnace linings. Sprayed asbestos.

Chemical & Insulating Co. Ltd.
Slab, block and pre-forms of 85 per cent magnesia and magnesium carbonate for temperatures up to 1,625 deg. F. Also insulating concrete for temperatures up to 2,400 deg. F.

E. J. Clay Ltd.
Insulation corkboard, cork sectional pipe coverings, granulated cork. Expanded polystyrene.

Consett Iron Co. Ltd.
All types of basic refractories including magnesite, magnesite-chrome, chrome-magnesite and chrome for the steel, copper and other non-ferrous industries. High alumina and full range of silica refractories for the steel and gas industries.

Cork Insulation & Asbestos Co. Ltd.
Moulded insulating material, a mixture of calcium and aluminium silicates available in pre-form and slab for temperatures up to 1,250 deg. F. Mineral wool, suitable for temperatures up to 1,200 deg. F. and also for cold-storage work. Available in loose wool, granulated wool, wool blocks, blankets and mattresses, reinforced with wire.

Derbyshire Silica Firebrick Co. Ltd.
Retort materials and firebricks for furnaces and for furnace insulation. Diatomaceous insulating bricks. Plastic refractory material supplied in drums. Fireclay for retort lining.

Dick's Asbestos & Insulating Co. Ltd.
Asbestos fibre pipe covering and slabs, for inside and outside use. Asbestos and hair felt pipe coverings for steam. Cork insulating slabs and pipe coverings for brine and ammonia. Magnesia and asbestos slabs and pipe coverings. Compressed sectional pipe coverings for cold water. Asbestos rope and lagging. Asbestos mattresses and insulating jackets. Anti-thermic cement and bricks for furnace linings. Sprayed asbestos.

Expanded Minerals Ltd.
Expanded mineral aggregate for insulating nests of pipework or for other situations where access is difficult. The material is free flowing. Suitable for temperature range −150 deg. F. to +735 deg. F.

Expanded Rubber Co.
Insulating rubbers for low-temperature applications.

J.R. Enterprises Ltd.
Foamed polystyrene pre-forms, mouldings and slab.

Fibreglass Ltd.
Pre-formed pipe sections and resin-bonded slabs, reinforced with wire. Wire reinforced mattress, strip and bandage material. Jackets for domestic water cylinders. Building and roof insulation.

General Refractories Ltd.
Insulating bricks for re-heating and forging furnaces. Insulating concrete for furnace and boiler foundations and for insulation of furnaces. Special concrete for application by gun. Insulating loose fill and cements made from diatomaceous powder for use up to 1,652 deg. F. Plastic insulation material supplied in dry powder form for boiler, high-pressure steam and arch insulation up to 1,832 deg. F. Hard-setting finishing coats for same.

Jablo Plastics Industries Ltd.
Foamed polystyrene for building insulation, the material being bonded to felt.

W. Kenyon & Sons (Thermal Insulations) Ltd.
Rock wool, asbestos, foamed polystyrene, cork pre-forms, mattress, slabs, loose rock-wool. Vermiculite-based compositions.

Kitson's Insulations Ltd.
Asbestos rope, cord, millboard, cloth and mattress. Slag wool and mineral wool. Cork pipe sections and slabs. Pipe sections of 85 per cent magnesia and asbestos. Glass fibre sectional pipe coverings and flexible mattresses.

Kingscliffe Insulating Products Ltd.
Insulating bricks and castables for various types of furnace and kilns.

Morgan Refractories Ltd.
Firebricks for furnaces, high-temperature flue linings, oil stills, kilns, insulating bricks. Special cements for use with these applications. Cement gun refractory concrete.

Newalls Insulation Ltd.
Preformed sections, slabs and plastic powder of 85 per cent magnesia. Also high-temperature pre-forms and slab which can be used underneath the 85 per cent magnesia type. Composite types available. High-temperature mouldable insulation. High-temperature mattreses of 85 per cent magnesia with asbestos cover. Asbestos insulation pre-formed sections and slabs. Flexible asbestos felt strip for pipe insulation. Sprayed asbestos insulation. Insulating bricks.

Potters Insulations Ltd.
High-temperature sections (preformed). Asbestos composition slabs.

Precision Rubbers Ltd.
Silicone rubber in solid sheet for the insulation of cabins or storage bottles where weight is not of prime importance. Silicone expanded rubber suitable for aircraft cabin insulation. Silicone foam.

E. J. & J. Pearson Ltd.
Refractory bricks and concrete.

W. R. Roberts Ltd.
Sprayed asbestos for thermal insulation and sound absorption.

Schofield H.I. Products Ltd.
Compressed mineral wool pipe sections. Expanded bead polystyrene for cold insulation purposes, available in slabs, slotted slabs, lags and pre-formed sections.

Sprayed Insulations Ltd.
Sprayed asbestos insulation for thermal insulation, condensation control and sound absorption.

Stillite Products Ltd.
Semi-rigid slabs made from mineral wool fibres for both heat and sound insulation. Flexible mattresses and felted sections, having wire mesh, expanded metal, flameproof scrim and asbestos cloth coverings, suitable for pipework, ducts and vessels with surface irregularities. Insulating resilient slab for furnace insulation. Semi-rigid mineral wool pipe insulating sections for range 400-1,500 deg. F. Pelleted mineral wool for heat, cold and sound insulation, food containers, cookers and the building industry.

Shell-Mex & B.P. Ltd.
Sheathing system for factory chimneys to prevent condensation using asbestos braid spacers.

Stewart & Gray Ltd.
Foamed glass in brick and slab form mainly for cold insulation, but also for building insulation.

Turner's Asbestos Cement Co. Ltd.
Glass fibre and sprayed asbestos systems of roof insulation.

Universal Asbestos Mfg. Co. Ltd.
Insulating systems for walls and roofs.

Versil Ltd.
Glass fibre woven wraps, available as pre-formed units for pipes, valves, bends, etc. Both rigid and flexible types available, as well as types covered with corrugated metal sheeting for boilers and storage tanks up to 1,000 deg. F. Blankets and mattresses. Glass felt, tissue and rovings.

Veedip Ltd.
Expanded polystyrene slab and pre-forms for cold insulation.

Winn & Coales Ltd.
Tapes and sealing compounds for the application and sealing of insulation.

POLYURETHANE FOAMS

The following manufacturers also produce polyurethane foams:

Flexible Foams
Aeroprene Products Ltd.; Dunlop Rubber Co. Ltd.; Kay Bros. Plastics; Lintafoam Ltd.; McCrae & Drew Ltd.; Plastikade (Manchester) Ltd.; Price Bros. & Co. Ltd.; Sorbo Ltd.; Volcrepe Ltd.

Rigid Foams
Andersons Insulating Co. Ltd.; Bells Asbestos & Eng. Co. Ltd.; J.D. Insulating Co. Ltd.; McEwan Insulators Ltd.; Mersey Insulation Co. Ltd.; Miller Insulation & Eng. Ltd.; Newalls Insulation Co. Ltd.; Polyisocyanate Applications Ltd.; Washington Chemical Co. Ltd.

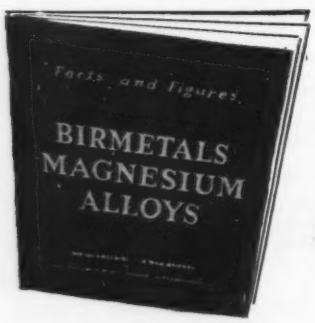
Sprayed Rigid Foam
J. W. Roberts Ltd.

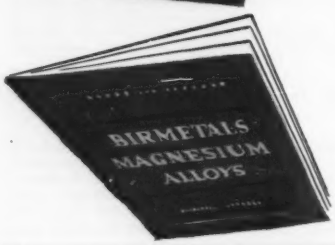
Cut Foams, Sections
Martin Goacher & Co. Ltd.; Volcrepe Ltd.; Goshawk Shipyards Ltd.; Rowan & Boden Ltd.; Timber Treatments Ltd.

EMD 1012 for further information

an eye to the future

MAGNESIUM ALLOYS





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GRAPHITE NOW IN FIBRE AND FABRIC FORM

FROM OUR OWN CORRESPONDENT

GRAPHITE'S unique combination of high-temperature strength, chemical inertness, high electrical and thermal conductivity and self-lubricating characteristics is now available in the form of flexible fibres or fabrics. Graphite textiles are now being produced in developmental quantities by a process developed by the National Carbon Co., a division of Union Carbide Corp.

The starting material for the process is a synthetic fibre, such as rayon. The fibre may then be converted directly to graphite as a fibre, or be pre-woven into the type of fabric desired—braids, felts or fabrics. The cloth is then treated at temperatures of the order of 3,000 deg. C., which graphitises the synthetic fibre, producing a fabric the fibres of which are 99·9 per cent pure graphite. The crystalline structure of such fibres is similar to that of conventional manufactured graphite.

Properties of fabrics, of course, depend on the type of fibre and weave. Individual graphite yarns have shown tensile strengths as high at 15,000 p.s.i. Other properties of fibres or fabrics are similar to those of conventional manufactured graphite.

One of the most promising applications for graphite fabrics is as a reinforcing material for plastics, ceramics or refractories for high-temperature applications, such as rocket nozzles and nose cones.

In the chemical industry such fabrics could be used for bag-type filters for hot non-oxidising gases, for handling corrosive fluids, in electrostatic precipitators, in curtain walls and as flame arrestors.

Electrical uses could include resistance-heating elements, both for industrial high-temperature applications as well as for low-temperature space heating. The cloth can be metallised by plating, spraying or vacuum deposition to provide electrical connections.

Mechanically, the combination of high-temperature strength and self-lubrication may make the material useful for valve packings and gasket materials for high-temperature seals.

New Vinyl-coated Steel

Strong competition for vinyl-metal laminates is expected to be provided by a comparatively inexpensive (20-35 cents per sq. ft.) vinyl coated sheet material developed by the United States Steel Corp. Conventional vinyl-metal laminates are produced by pressure bonding vinyl sheet to metal at elevated temperatures. However, the new vinyl coated steel is produced by roller coating a liquid vinyl plastisol to pretreated steel sheet and then curing. While still hot, the strip is passed through embossing rolls which can apply a very wide variety of textures.

The vinyl coating can be produced in thicknesses of 8-20 mm., in increments of 1 mm. The coating has a hardness of 60-90 deg. Shore Durometer, and provides excellent resistance to scuffing and abrasion. In addition, it will not stain after exposure to such diversified media as die lubricants, alkaline cleaners, ink, alcoholic beverages, detergents, acid cleaners, nail polish and fruit acids.

Vinyl coated steel can withstand considerable exposure to heat without loss of colour, texture or adhesion. It will withstand a temperature of 70 deg. C. continuously and 100 deg. C. for as long as two days. The material will soften appreciably at 180 deg. C. and will char above 200 deg. C.; however, it will not support combustion.

A very significant advantage of the vinyl coated steel is the ease with which it can be fabricated. The material can be readily sheared, slit, punched, lock seamed, stamped, drawn or roll formed without damage to the coating. It can be fastened by almost any method of mechanical fastening and can be successfully welded.

Ceramic Coatings for Thermal Insulation

Advanced laboratory development of reinforced ceramic coatings is under way to produce coatings for aircraft and missile engines that will (1) withstand temperatures of 1,650 deg. C. and above for long periods; (2) markedly reduce the operating temperatures of the metal components to which they are applied; and (3) withstand the severe mechanical vibration of power-plant operation.

Developed by the Marquardt Aircraft Co., the coatings are reinforced with continuous lengths of metal or with ceramic or metal fibres which not only reinforce the coating material but provide a means of firmly anchoring the coating to the base metal. Typical continuous metal reinforcements that have been used are wire mesh or expanded metal made from mild steel, 300 stainless steel or molybdenum. The wire mesh or expanded metal is brazed or resistance welded to the base metal before the coating is applied. In the other reinforcing method, metal or ceramic fibres are randomly mixed in the ceramic coating mixture prior to application. Typical fibres that have been used for this type of reinforcement are corrugated metal strips made from mild steel, 300 stainless steel and tantalum, and ceramic fibres made from aluminium silicate and quartz.

A number of ceramic coating materials have been used with the above reinforcing media. Typical of these coating materials are (1) sodium silicate base materials containing various refractories such as alumina, mullite, kyanite and silica; (2) phosphate-bonded alumina, zirconia and chromia; and (3) pure alumina and zirconia. The pure alumina and zirconia are usually applied by flame spraying and the phosphates and silicates are applied by trowelling.

The performance of each type of coating depends on the type of reinforcement used and the composition of the coating material. In general, the coatings can meet the following performance specifications:

1. Withstand continuous temperatures of 1,350-2,200 deg. C.
2. Provide a temperature drop of 10 deg. F. for each 0·001 in. of thickness (at a steady state heat flux of 10,000 B.t.u./sq. ft./hr.).
3. Provide a thermal conductivity of 5 to 10 B.t.u./sq. ft./hr./in./deg. F.
4. Have a density of 0·10 to 0·14 lb./cu. in.
5. Deposit to thickness of 0·1 to 0·5 in. and greater.
6. Provide emissivity in the range of 0·2 to 0·8.
7. Be capable of withstanding severe mechanical vibration, flexing, thermal shock and temperature recycling.

New Books

Metal Fatigue. *Edited by J. A. Pope* (*Chapman & Hall, 70s.*).

THIS book has its origin in a series of papers presented in a residential course held at Nottingham University, but it should not be assumed that the book is merely a collection of papers. Although the substance of each paper represents a chapter, they have been integrated into an informative volume. A general introduction, with information on corrosion fatigue, crack propagation and temperature effects, forms Part 1 of the book.

Part 2 covers high-temperature alloys, aluminium alloys, cast iron and non-ferrous metals, the latter chapters dealing with aspects of fatigue as applied to aircraft structures and the effect of welds and joints. The third section of the book discusses the reproduction of results in testing, bearing fatigue, fatigue of welded structures and aircraft structures.

Profusely illustrated, this book represents a practical, down-to-earth attempt to rationalise fatigue and offers sound value at its price.

Chambers' Technical Dictionary (*Chambers, 35s.*)

Present-day technology calls on the one hand for increasing specialisation, and on the other for an understanding of other fields of industrial activity. This trend does not daunt the compilers of this dictionary, which has since its first appearance in 1940 run through seven revisions, and now appears in a new revised edition. While keeping up-to-date, it wisely avoids an attempt at exhaustive treatment of any of the 120 branches of science and industry with which it deals and, as a result, it is a most valuable guide that will be in frequent use.

Civil Engineering Contracts Organisation. *By John C. Maxwell-Cook* (*Cleaver-Hume, 22s. 6d.*).

An interesting book shedding light on the programming of civil engineering contracts and the relationships between personnel involved. A comprehensive glossary of terms is included and forms a useful reference.

The New Materials. *By Gerald Leach* (*Phoenix House, 9s. 6d.*)

This book is written specially for young people, but to both young and old it is a fascinating book written in a plain, forthright style which leaves little to be desired. The author is to be particularly congratulated on the clarity, in non-technical terms, of the chapters dealing with plastics, a subject from which it is only too easy to emerge completely confused. Whatever the age of the reader, the result of reading this book will be a clearer concept of the part which modern materials play.

Corrosion of Metals by Vapours from Organic Materials. *By Vera E. Rance and H. G. Cole* (*H.M.S.O., 2s.*)

Instances have been observed of metal corrosion in restricted spaces by reactive organic vapours, such as those that may be evolved from woods, glues, paints, varnishes and plastics, though comparatively little has been published on the subject. This booklet gives the results of a survey of instances of metallic corrosion in service or under laboratory conditions, classified according to the source of vapour. This information, the discussion and conclusions will be of interest to all concerned with the packaging and storage of metal components or with enclosed electrical equipment.

Phenolic Resin-bonded Paper Tube. (*H.M.S.O., 3s. 6d.*).

This book is the ninth of a series of Ministry of Supply reports on the behaviour of plastics materials in the tropics. It surveys the results of tests made at several sites in Nigeria over a period of two years.

Buyers' Guide, 1959. (*"The Engineer", 9s. 3d.*).

The new edition of this reference work has been published, following closely the formula which has provided it with such success in previous years. There are over seventy more pages in this edition, some of which are occupied by a new feature providing addresses of British state industries and scientific departments.

The Solid State for Engineers. *By M. J. Sinott* (*Chapman & Hall, £5*).

This book successfully bridges the gap which exists all too often between the designer wishing to use the material and the physicist who, in his fundamental work, provides the property of the material.

The first part of the book is limited to the structure of matter with chapters on crystallography, equilibrium, covalent and molecular solids. Elastic and plastic deformation is discussed, together with the mechanical and thermal properties of solids. Electronic, magnetic, dielectric and optical properties are also explained.

The subject-matter is concisely written with many excellent diagrams, and the author takes particular care to refresh his reader by a brief explanation of each scientific term introduced.

Surface Defects in Ingots and their Products. (*Iron & Steel Institute, 25s.*).

This is the second edition of a special report first issued in 1951, which aimed at introducing some uniformity in the nomenclature applied to the more common defects. The present volume has an additional section illustrating surface defects in steel strip products.

Conversion Factors and Tables (B.S. 350 : Part 1 : 1959). (*B.S.I., 15s.*)

The first part of this standard has now been published in revision in a 114-page, fully-indexed volume. The standard, enlarged in scope by its revision, covers, broadly, units, their abbreviations, conversion factors and detailed conversion tables for a wide range of subjects falling under the general headings of metrology, mechanics and heat.

Part 1 gives extended basic information on units, together with the standard abbreviation for each unit or combination of units considered. Included also are comprehensive tables of conversion factors, showing the relationship between British and metric units used in the measurement of a given physical quantity. Summary tables of units and conversion factors are also included, together with an appendix on thicknesses of sheets and diameters of wires.

LETTER TO THE EDITOR

Why Only The Metric System?

Sir,

Your editorial on "The Metric System for Britain" (April issue) prompts me to appeal to you before it is too firmly fixed in everyone's mind that the metric is the only alternative to the imperial system.

Compared to the cumbersome Roman system, the Arabic numerical system working in tens—the decimal system from which sprang the metric system—was an enormous advance and enabled calculations to be performed much more easily.

But what a pity there was no philosopher-mathematician of sufficient genius to suggest the system of working in twelves—the duodecimal system. The advantages of this system should be known to your readers; suffice to say that the principal one is that thirds and quarters become whole numbers. This is why the "dozen" is used throughout the U.K., the U.S.A. and the Commonwealth.

If we are to change our systems, let us very carefully consider whether we ought not to steal a march on the metric camp and evolve a complete new set of duodecimal units. The advantages would surely persuade the metricians to change to our units.

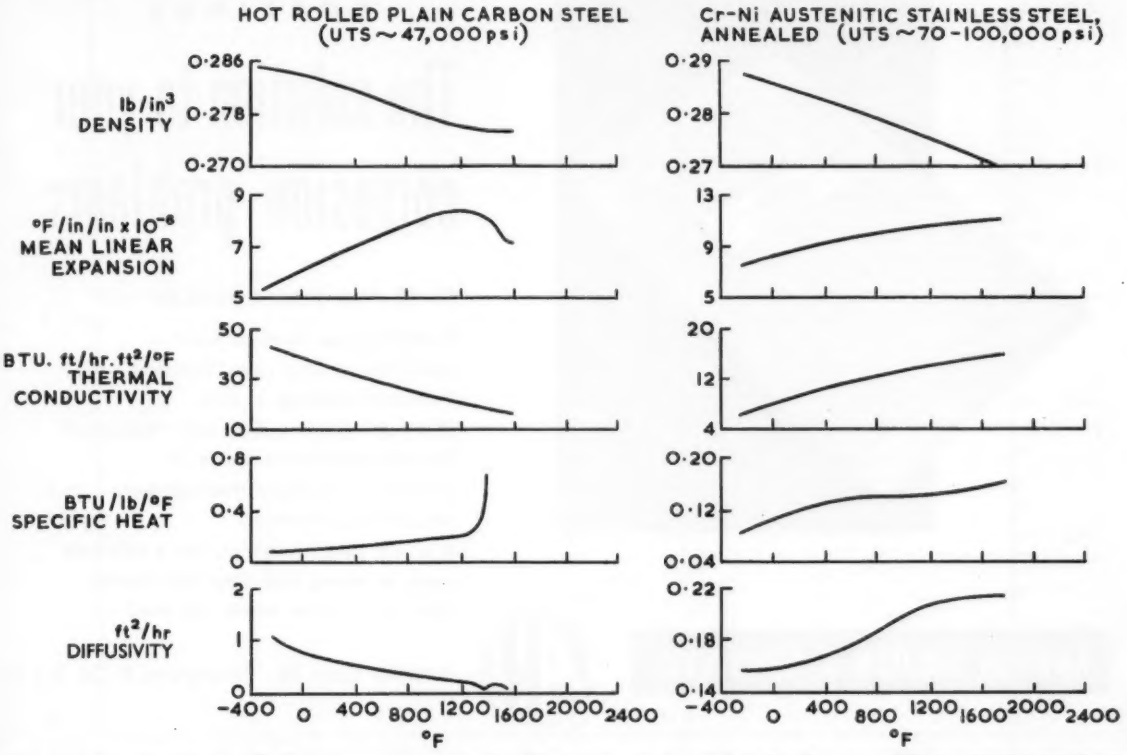
N. S. Stewart

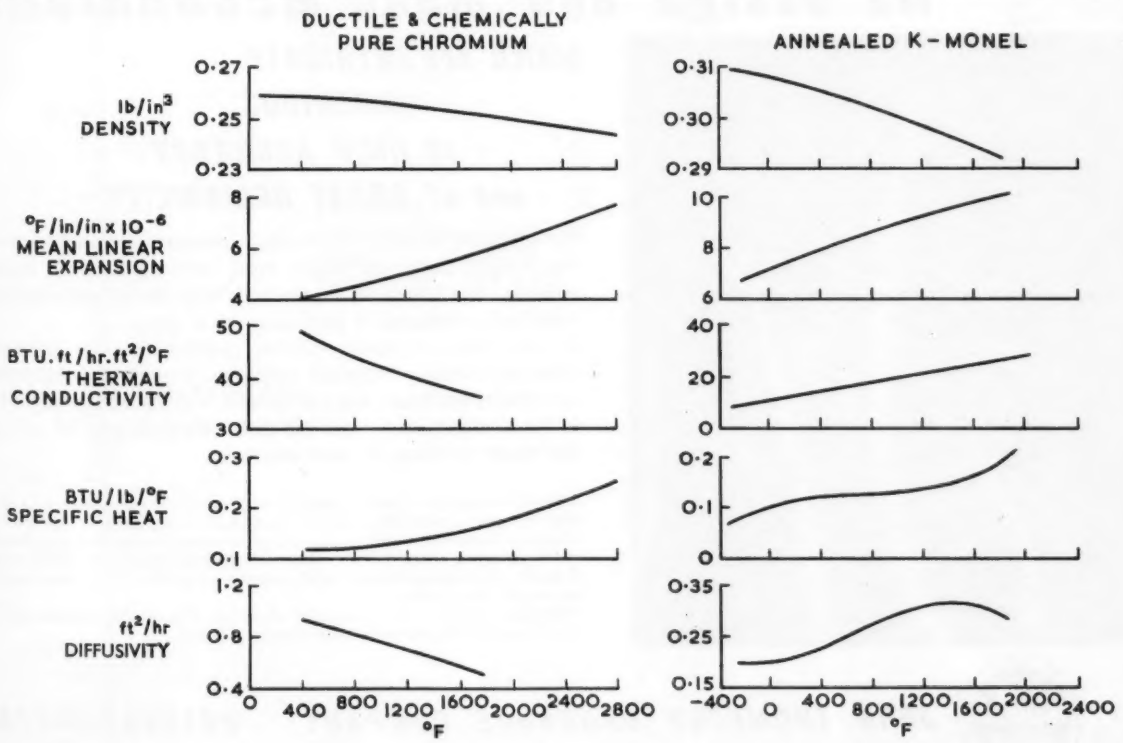
259 Uxbridge Road,
Hampton Hill,
Middx.

THERMAL PROPERTIES OF CARBON STEEL, STAINLESS STEEL, CHROMIUM AND K-MONEL

Engineering Materials and Design

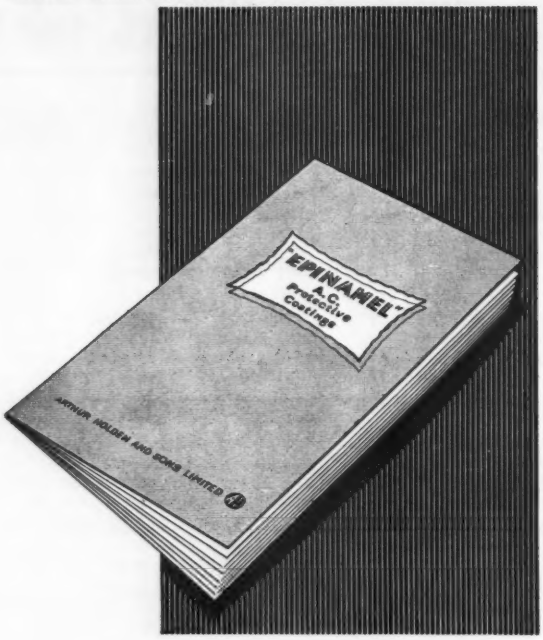
DATA SHEET No. 16





Data from A.S.T.M. special technical publication No.227, by Lucks and Deem.

EMD 1013 for further information



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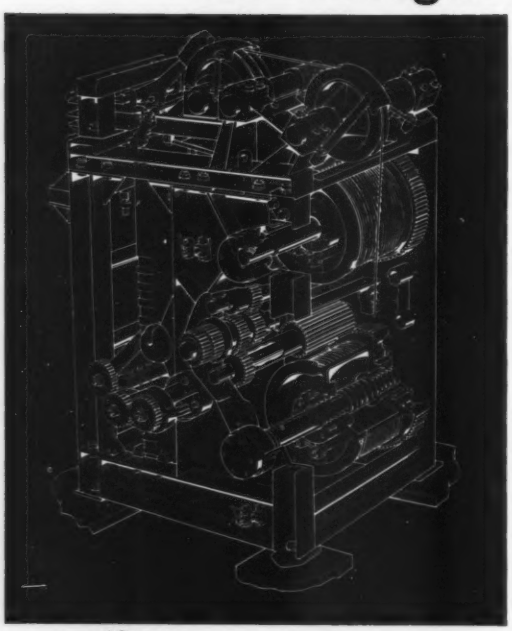

We specialise in out-of-the-ordinary mechanisms, such as those for control purposes, which must have qualities of highest precision (no backlash, for instance) and the utmost reliability under all conditions of service.
If you have a special-purpose requirement, for whatever purpose, needing unusual skills in design and extremely competent workmanship, call in John Thompson Ordnance Co. at the commencement and let us see what we can do to take the whole problem off your shoulders.

The illustration is a Chute Winding Gear, part of the mechanism of a 50 ft. high machine, controlling a grab which inserts and removes fuel element chutes into and out of the Reactor Pressure Vessel at the Berkeley Nuclear Power Station. The winding gear incorporates many ingenious design features, but above all has to be of extreme reliability, since there must be no possibility of failure.
Manufactured by John Thompson Ordnance Co. to the requirements of A.E.I.—John Thompson Nuclear Energy Co. Ltd.

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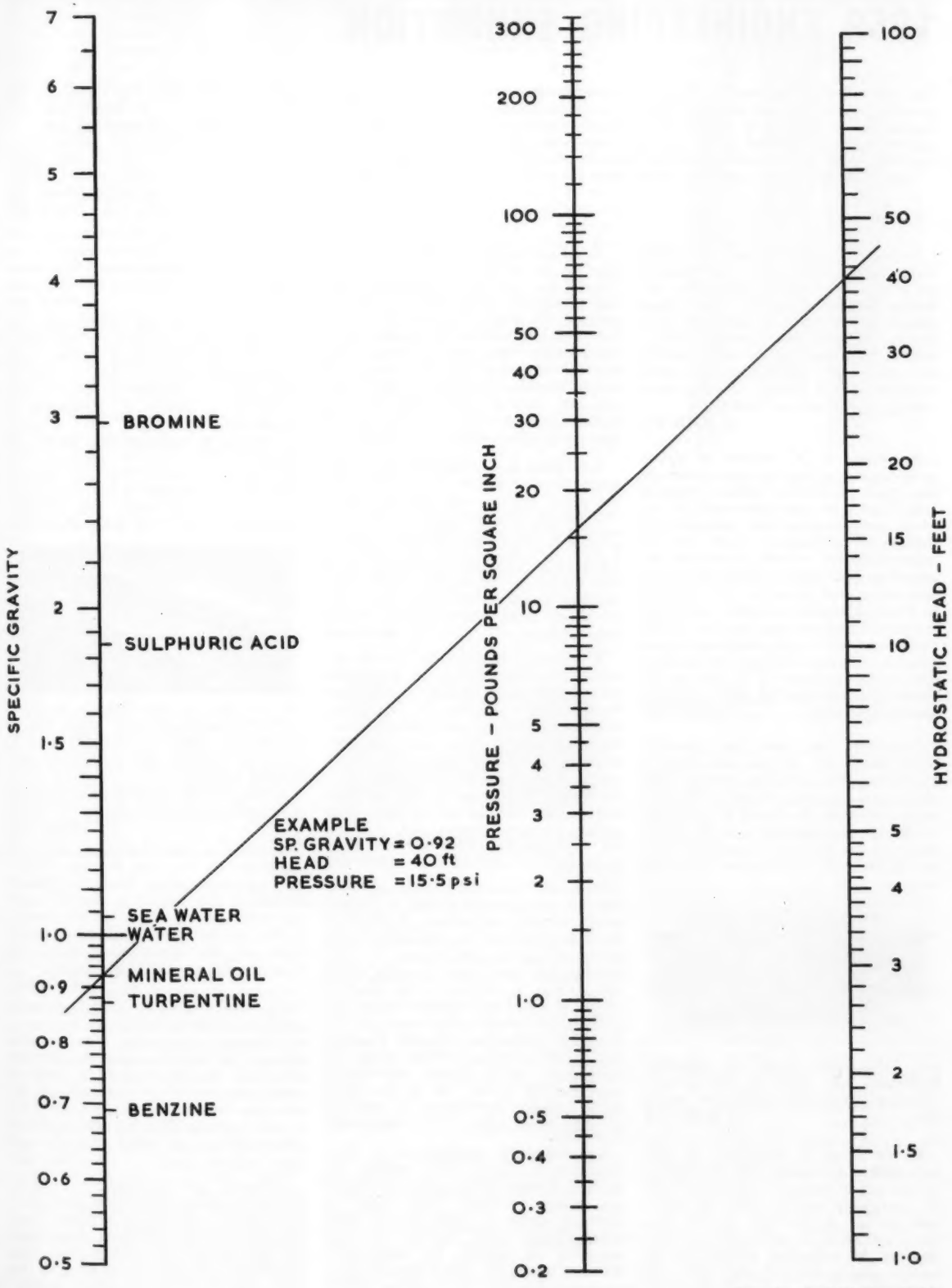
PRESSURE HEADS OF VARIOUS LIQUIDS

Engineering Materials and Design
DATA SHEET No. 17



Data sheet by R.W. New, M.C.T.

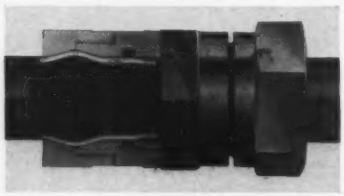
NUCLEAR ENERGY SETS THEME FOR 1959 ENGINEERING EXHIBITION

This year's Engineering, Marine, Welding and Nuclear Energy Exhibition has indicated primarily the impact that is being made on general engineering by rapid advances in nuclear power. Because of the stringent requirements that this imposes, many components taken for granted in the past have been redesigned along entirely new lines, resulting also in some remarkable improvements in other and more traditional products. Some highlights of new equipment seen there are given briefly on these pages:

Typical of new designs of pumps widely used in the nuclear and chemical industries are those produced by the **British LaBour Pump Co. Ltd.** These pumps are designed to handle a wide variety of fluids, many of them corrosive, at high temperatures and pressures, and one model incorporates a totally immersed seal to prevent air entry when running under vacuum conditions. **EMD 910**

A solution to the problem of scaling is by the use of gas bearings as seen on the stand of **Bristol Siddeley Engines Ltd.** These have been developed for use where contamination from lubricants or leakage to atmosphere could not be tolerated as, for example, in nuclear engineering. This type of bearing may be self-sealing, and therefore the unit can be totally enclosed. A further advantage is that the load-carrying capacity is said to increase with speed, temperature and pressure. These gas bearings are likely to have many applications in the textile, chemical, pharmaceutical, food and processing industries. **EMD 911**

Developed to meet the exacting requirements of modern high-pressure hydraulics, the KeelaTite coupling employs an O-ring seal, the end of the pipe being accurately pre-formed in a suitable die by oil pressure and it is this shape which is said to enable a pressure-tight seal to be made by tightening the union



nut. Other items shown by **Industrial Hydraulics Ltd.** were the liquid-sealed hydraulic accumulator and their micro filter. **EMD 912**

A new range of circulators by **Gilbert, Gilkes & Gordon Ltd.** for heating systems are of interest, as the circulators are completely isolated from the motor and provide a full-bore gravity flow when the pump is not operating. The unit can be connected directly to the heating mains without the need for special foundations, and will operate in any position. **EMD 913**

For many applications, it is an advantage for the pump and motor to be an integral unit and the **Worthington-Simpson** flameproof motor enclosure in the patented Monobloc construction constitutes a notable advance in pumping equipment design. This type of construction has the advantage that the pump and motor combine to form a single unit requiring only one shaft, thus ensuring perfect alignment. The pump is said to operate in any position. **EMD 914**

Lee, Howl & Co. Ltd. showed a wide range of rotodynamic and positive-displacement pumps including a 3-4-in. twelve-stage centrifugal pump, said to be capable of delivering 12,000 g.p.h. against a total head of 1,075 ft. at a speed of 1,470 r.p.m. Designed for dealing with coal slurries in coal washing plants, their 16-18-in. pump at 720 r.p.m. is claimed to deliver 7,000 g.p.m. against a total head of 80 ft. **EMD 915**

A positive-displacement rubber-to-metal self-priming pump was among the several new items shown by **Goodyear Pumps Ltd.** Available in Meehanite, bronze, aluminium and stainless steel, the extra cost of using these materials is offset by the small size in which only two moving parts are in contact with the liquid. Also shown for the first time was a unit pressure set complete with pumps, motors, starters and switches, etc., for supplying fresh and salt water to all parts of any size ship. **EMD 916**

With the widespread use of high-temperature and pressure piping in modern power stations and refinery plants, there has been a demand for high-performance expansion joints. An answer to this problem has been found by using metal bellows and, in addition to the standard range of cylindrical bellows which can be obtained in sizes from ½ in. to 6 ft. diameter, **Teddington Aircraft Controls Ltd.** were exhibiting a new range of rectangular units, some of which measured 24 ft. × 24 ft. An even larger circular unit 78 ft. in diameter is under construction. **EMD 917**

An interesting example of a fluid transmission valve was shown by **Richard Klinger Ltd.**, which is suitable for remote control. This valve is arranged either to open or to close automatically upon failure of the operating air supply, the diaphragm-operated automatic return piston valve consisting basically of a seatless piston valve. **EMD 918**

To fulfil the many and varied requirements in the field of atomic engineering, **I.V. Pressure Controllers Ltd.** are constantly developing new valves to suit special requirements. Among their many products is the revised marine steam reducers and an advanced design of thermo-dynamic steam trap. **EMD 919**

On show for the first time was the Flumax high-lift bronze safety valve produced by **British Steam Specialities Ltd.** which has fittings of stainless steel. **EMD 920**

In all industries the use of hydraulic and pneumatic actuators is increasing, and associated with this is an interesting development which is likely to find a wide field of application. This is the precise servo control by **Hydraulics & Pneumatics Ltd.** for the accurate positioning of hydraulic and pneumatic actuators. The valve is positioned on the cylinder to avoid time lag and the operation of the valve is by remote control which may be either fluid- or electrically-controlled. Also being shown for

the first time was the automatic variable-delivery constant-pressure pump which is said to move automatically into a no-stroke position on reaching a pre-selected pressure.

Another servo actuator giving precise positional control was shown by Rotol Ltd. **EMD 921**

In extensive use by leading petroleum companies is the new Fullway heavy-duty gunmetal valve. Made by **Robert Harlow & Son Ltd.**, it is equally suited to water and steam. A notable feature is that the forces on the handwheel are taken on the strengthened cover and therefore do not distort the spindle. **EMD 922**

Aluminium bronze is being more widely considered today by designers, and **Langley Alloys Ltd.** were showing examples of rolled sections, forged tube sheets for heat exchangers, as well as rolled bar, stampings and castings. Of particular interest were the castings in a new low-cost stainless steel specially developed for use with sulphuric and other mineral acids. **EMD 923**

Following the installation of a new 12-ft-wide rolling mill, aluminium plate up to 10 ft. wide will be available from the works of the **Northern Aluminium Co. Ltd.** by the end of this year. This equipment, the first of its kind in the U.K., was shown by an artist's impression on the company's stand. **EMD 924**

The latest development of Alzen bearing material is extruded bar, either solid or hollow. This is made by **Hill, Alzen (Sales) Ltd.** to a close tolerance, thus avoiding lengthy machining operations. Approximately half the weight of bronze, it is claimed to have a longer bearing life, and up to 40 per cent saving is said to be possible on a finished product. **EMD 925**

For applications requiring exceptional mechanical properties, Prescollan polyurethane rubber may provide an answer, and typical components made from this material by **Precision Rubbers Ltd.** were shown on the John Bull stand. Prescolastik and Viton rubbers are of particular interest where high temperatures are encountered and fuel and acid resistance are required. **EMD 926**

Power transmission is an interesting example of how nuclear energy requirements have influenced new and improved designs. In particular, the Berkeley nuclear power station has presented many engineering problems which, in turn, have produced equipment capable of dealing with very much increased powers. Typical is the **Vulcan-Sinclair** double-circuit scoop trim fluid coupling which has the advantage of minimum diameter, as only half the power is transmitted through each working circuit. **EMD 927**

Also for the same power station is the 90-in. dia. bore ball race constructed by the **Cooper Roller Bearings Co. Ltd.** This race contains 116 balls, each 2½ in. in dia., the precision being such that, when unloaded, only 7 oz. applied at the periphery of the ring will overcome the inertia. **EMD 928**

The Twin Disc 1300 series single-stage torque converter is designed specifically for the requirements of modern high-speed diesel and petrol engines for heavy industrial powered equipment. With a speed range of 1,450 to 3,200 r.p.m. and a horsepower capacity of between 30 and 212, this converter is marketed by the **British Twin Disc Ltd.** **EMD 929**

The focal point of **Crofts (Engineers) Ltd.** display was two new types of universal mounting gear unit and the flexible resilient coupling known as the Croft-ring coupling. The primary feature of the universal units is their adaptability to a wide variety of mounting positions, shaft disposition and ratios of speed reductions. This coupling utilises radial nests of concentrically-mounted split-ring springs to provide torsional resilience and to cater for angular and parallel shaft misalignment. Claimed to be completely shock-absorbing, these couplings are said to transmit up to 80,000 h.p. **EMD 930**

In addition to their disc brakes, **Twiflex Couplings Ltd.** were exhibiting a free overrun coupling with enables torque to be transmitted in one direction only and, in the event of overspeeding, the unit prevents the transmission of torque back to the primary driving unit. **EMD 931**

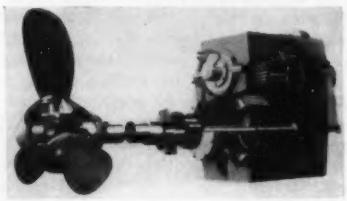
Hydraulic Installations Ltd. exhibited for the first time examples of their complete range of hydraulic axial piston pumps, motors and transmissions. The range includes both variable and constant displacement units of which, it is said, the overall efficiency is as high as 90 per cent. **EMD 932**

Among the most interesting developments in bearings were those shown by the **Glacier Metal Co. Ltd.** One of these is a self-contained, self-aligning bearing assembly using a new principle which enables a single bearing surface to carry both journal and thrust loads. The anti-whirl turbine bearing is also of interest, and was designed to meet a problem, common among high-speed turbines, that arises from the instability of the oil film. **EMD 933**

Mobil's exhibit concentrated on their successful efforts to solve the lubrication problems associated with free piston gasifiers and problems in nuclear power stations. Transport was also featured in their display, particularly the properties of their new marine cylinder oil, No. 593. For road transport it is claimed that, with very few exceptions, all vehicles can be lubricated all the year round with only three products. **EMD 934**

Another company developing oils for use in the nuclear engineering industry is **Wakefield-Dick Industrial Oils Ltd.**, who emphasised their range of nuclear radiation-resistant lubricants. **EMD 935**

Variable-pitch marine propellers have gained much popularity and the Hindmarch/Berg propeller was on show for the first time in this country. Manufac-



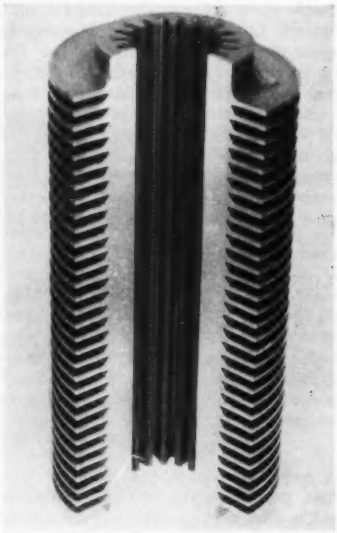
tured by **T. Hindmarch & Co. Ltd.**, the variation is effected hydraulically. **EMD 936**

A further means of raising the efficiency of a diesel engine is by the use of exhaust turbo chargers. These form a new venture of **Rotol Ltd.**, who have a contract to supply these units to the Caterpillar Tractor Co. **EMD 937**

When emergencies such as overspeeding of a turbine, excessive end movement of the rotor, loss of vacuum or lubrication pressure occur, the balance of pressure on the piston of a self-closing valve by **Weir Valves Ltd.** is disturbed, causing the automatic closure of the main steam supply to the turbine. **EMD 938**

Another protection device provides automatic and continuous protection against overspeeding, falling pressures or excessive temperatures on diesel and petrol engines. Operated electrically, the device made by **Smith's Industrial Instruments Ltd.** incorporates a speed, pressure and temperature switch. **EMD 939**

To promote the maximum efficiency in heat transfer, a new range of extended-surface seamless steel tubes have been produced by **Tubes Ltd.** These con-



sist of helical fins resistance welded to the outside of the tube which has internally forged axial ribs, thus giving a substantial increase in heating surface. **EMD 940**

Another diesel engine device being exhibited for the first time was the new high - temperature thermometer. The element is made of a special material which is free from oxidation up to 1,400 deg. F., the instrument range being 200-1,200 deg. F. Also shown by the **British Rototherm Co. Ltd.** were two new temperature controllers. **EMD 941**

A new electric governor, the first of its type to be built in Britain, has been developed to give very accurate control of prime movers for a.c. generating sets where the variation in frequency must be kept to a minimum. Shown on the stand of **Ardleigh Engineering Ltd.**, this governor operates on the principle of continuously measuring the electrical load and then positioning the throttle or fuel rack according to the signal produced. The positioning takes place before the engine has time to alter its speed, as the signal is directly proportional to the alternator output. **EMD 942**

One of the most interesting uses of nylon as an engineering material has been the marine propeller. Developed by Hundested Motor & Propeller Fabrik A/S of Denmark and shown on the stand of **Small & Co. (Lowestoft) Ltd.**, these propellers have a reversible pitch and are suitable for yachts, barges and fishing vessels. In addition to their immunity from scale or marine growth, they have more resilience than metal propellers and, because of their lower weight and the consequent inertial masses involved, the critical speed of the shafting is unlikely to be reached within the normal operating range of the engine. **EMD 943**

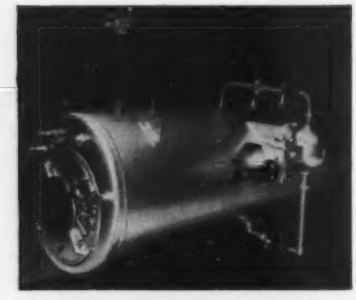
Engineering Exhibition (contd)

Pumps and compressors, oil-burning equipment, and hydraulic pumps and motors were among the various units from the three divisions of **Hamworthy Engineering Ltd.** Exhibited for the first time in Britain was the external bearing screw pump designed to handle all kinds of viscous liquids. Fluid is drawn from each end of the pump and the screws are then in hydraulic balance, thus eliminating axial thrust. The design of the screws ensure a non-pulsating, non-turbulent discharge. **EMD 944**

One of the many new finishes shown was the Plusbrite bright nickel plating process of **Albright & Wilson (Mfg.) Ltd.**, which is said to offer better physical properties than have been hitherto possible, and is of particular interest to manufacturers of motor accessories where a high standard of serviceability and ductility is required. **EMD 945**

A new addition to the range of protective pretreatments by the **Walterisation Co. Ltd.** was a cold spray phosphate treatment that promises to have many applications. Also of considerable interest were the platinised titanium anodes for cathodic protection by **I.C.I. Ltd.** **EMD 946**

Raising the thermal efficiency of a diesel engine from 36-80 per cent is a considerable achievement and is claimed to have been accomplished by **Maxim Silencers Ltd.** in their heat-recovery unit, designed for effective silencing of engine exhausts and at the same time



utilising the waste heat of the gases to produce steam or hot water for heating or processing. With this silencer approximately 1,200 B.t.u./b.h.p. are said to be recoverable. **EMD 947**

An X-ray microanalyser displayed by **Metropolitan-Vickers Electrical Co. Ltd.** illustrates a new technique for quantitative and qualitative chemical analysis of compounds containing elements in the range uranium (92) to titanium (22). **EMD 948**

Introduced for the first time was the new Auto Spray-fuse unit designed by **Deloro Stellite Ltd.** to mechanise their hard-facing process. This method of protecting components against wear, heat and corrosion consists of an initial deposition of Stellite powder by metal spray, followed by fusing to the base metal. **EMD 949**

A special gun has been designed by **Metallisation Ltd.** which, together with the powder feed units, makes it possible for heat-fusible powders such as nylon, alumina and hard-facing alloys to be sprayed. **EMD 950**

Kerry's (Ultrasonics) Ltd., sole U.K. distributors for Mullard low-power ultrasonic equipment, showed a new engraving tool developed for machining small holes of any shape in hard and brittle materials such as diamond and tungsten carbide. The tool may be operated either as a hand tool or in a precision drill, or may be mounted in a normal pantograph - type engraving machine. **EMD 951**

The well-known **Napier** Deltic engine was shown for the first time as a turbo-charged version. Other exhibits by this company were titanium welded parts and examples of high-duty seals. **EMD 952**

A range of filters made in two basic materials was shown by **Morris & Ingram,** using Micro-Klean wood or cellulose cartridge and Poro-Klean sintered stainless steel. **EMD 953**

The new 72N27 dynamic balancing machine by **W. & T. Avery Ltd.** is suitable for rotors which cannot be driven by means of an end drive. In this machine it is driven by means of a belt passed around some convenient position on the periphery, the angular location being determined by means of a photocell pick-up device. It is particularly suited for rotors between 4 oz. and 15 lb., the maximum rotor diameter being 4 in. For a series of similar rotors, a calibration chart can be prepared to convert the readings from the balance into units of correction such as number of washers to be added or depth of holes to be drilled. **EMD 954**

The new silicon rectifier-transformer represents a bold advance in the technology of electric welding and was shown together with other welding equipment manufactured by the **Lincoln Electric Co. Ltd.** A complete range of fused and unfused fluxes for hard surfacing and for welding mild steels, and alloy steels containing niobium, molybdenum and chrome-molybdenum were also featured on this stand. **EMD 955**

Prominent among the exhibits of **Quasi-arc Ltd.** was the equipment for vertical welding (Unionmelt), in which process a molten pool forms between the edges of the plates to be welded; the sides of the pool are retained by means of copper dams which are automatically raised with the welding head as the seam progresses. Other welding developments include the self-propelled twin-fillet welder, and a new welding electrode, Ferron No. 3, especially developed for the atomic energy industry. The deposits from this electrode have exceptionally high impact strength at low temperatures. **EMD 956**

The Hancoline automatic electronic oxygen profiling machine represents a major advance in profile cutting in as much that it dispenses with the need for a template. All that is required is a pencil line drawing, the machine compensating for the width of cut. This machine is a product of **Hancock & Co. (Engineers) Ltd.** **EMD 958**

Formagrille is a readily-adaptable section made in a tough plastics material in a range of colours to form grills of any size, and may be arranged to give air flow either forward, to the left or to the right in the horizontal plane. To allow full control in the vertical plane, deflectors may be fitted. A product of **Hall & Kay Ltd.** **EMD 959**

Guest, Keen & Nettlefolds Ltd. exhibited their comprehensive range of fasteners, including the high-strength friction grip bolts and Torshear bolts which are used in large quantities in structural works on power stations and refineries. **EMD 960**

A further means of eliminating the use of templates is the computer-controlled gas cutting machine which was designed to form an integral part of the modern shipyard. This machine, the first of its kind in Britain, was developed by the **British Oxygen Co. Ltd.** and works from the instructions on a magnetic tape produced by means of a Pegasus computer in conjunction with a digital differential analyser. **EMD 961**

Specially designed for welding plastics-coated steel sheets, the machine produced by **Hirst Electronic Ltd.** is compact and easy to handle, and will fill a need arising from the increased use of this material. **EMD 962**

Designer's Diary

May 11-21. Zeiss industrial instrument exhib. 6 Cavendish Sq., London, W.1. (Also at Glasgow later in month.)

May 21-27. Int. Transistor Exhibition. Earls Court, London.

May 26-28. Exhibition: "Sintox Industrial Ceramics and Industrial Equipment". Engineering Centre, Birmingham.

June 1-5. B.E.D.A. British Electrical Power Convention, Torquay.

June 2-5. Mond Nickel Co. Exhibition of nickel, platinum metals and S.G. iron. Cutlers Hall, Sheffield.

June 4. B.S.I. and Inst. Prod. Eng. Standards Engineers' Conference. Connaught Rooms, London.

June 9. Symposium on Interferometry. National Physical Lab., Teddington.

June 17-27. Int. Plastics Exhibition and Convention. Olympia, London.

June 22-25. British Computer Society, 1st conference. Cambridge.

Expansion, contraction and lateral movement of pipe work under extreme conditions of temperature and pressure is no problem to the engineer who has been wise enough to contact and consult TEDDINGTON technicians. Teddington Bellows Expansion Joint cylinders are butt-welded from highly finished cold rolled stainless steel sheet. Convolutions are introduced to give the bellows their characteristic flexibility. Nuclear, chemical, marine and gas engineers acknowledge their efficiency and superiority over many older forms of expansion joint. Wherever pipe-work is subjected to vibration or movement in any direction, a Teddington Bellows with a suitable end-fitting will solve the problem.

SEND FOR BROCHURE No. X67

Teddington Bellows are produced in technical collaboration with the Solar Aircraft Co., U.S.A.

TEDDINGTON BELLOWS

EXPANSION JOINTS

TEDDINGTON AIRCRAFT CONTROLS LTD. (*Industrial Bellows Division*)
Ammanford, Carmarthenshire. Tel.: Ammanford 2255

WHAT'S NEW IN MATERIALS & COMPONENTS

Beryllium Copper

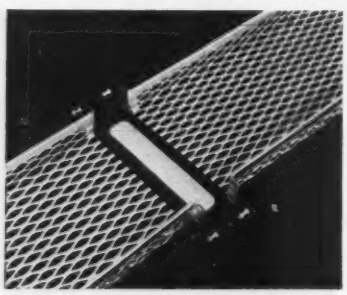
A new and lower-priced alloy of beryllium copper is now being marketed in this country. Known as Beryldur, this alloy has been developed to meet the need for a material which is stronger than brass or bronze and also having better electrical conductivity, but at a lower cost than beryllium copper alloys hitherto available. It is claimed that good wear and fatigue resistance have been retained in this alloy, which can be hardened by a low-temperature heat treatment. It is also said to have good corrosion resistance and easy formability. Beryllium Smelting Co. Ltd.

EMD 879 for further information

Cable Trays

Expamet heavy-duty trays consist of a range of units designed specially to provide a complete system for carrying heavy cables. The units are prefabricated from expanded steel which has a smooth, flat surface, free from rough or sharp edges. All units are hot spelter galvanised to protect them from corrosion in external and internal work. The units making up the system are standard, providing for future extensions or replacement of parts if necessary.

Among advantages claimed are that



the expanded metal mesh is lighter to handle than solid trays, so that weight of supporting structures can be reduced and the simple and speedy method of joining up the units to any planned arrangement lowers cost of installation. It is also said that cables can have higher ampere rating because of ventilation through the meshwork. The Expanded Metal Co. Ltd.

EMD 880 for further information

Corrosion-resistant Alloys

Xaloy and Xaloy-306 were created to answer the most severe wear and corrosion problems of many industries, most notably those engaged in the processing of plastics and rubber, as well as pump liners and plungers for the petroleum industry. Formerly produced in the U.S.A., these alloys are now available in the U.K.

Xaloy is a high-boron cast-iron with certain alloy additions essential to its hardness and wear resistance. Xaloy-306 is a highly corrosion-resistant alloy consisting principally of nickel and cobalt, containing complex carbo-borides giving the alloy hardness and wear resistance.

These alloys have been developed with specific properties that are said to protect extruder cylinders from severe abrasion and destructive actions of certain thermoplastics and compounds used in plastics and rubber extrusions, as well as other products.

Advantages claimed from their use for lined cylinders include increased production and long life for extrusion equipment. Brooks (Oldbury) Ltd.

EMD 881 for further information

Gloss Finish

Cadolex 4/2 is designed as an industrial one-coat gloss finish. It is guaranteed free from cellulose (and not therefore subject to cellulose regulations), but is said to dry in 10-15 minutes and be handled in about 40 minutes. It is also said to have exceptional adhesion and flexibility. It is based on proprietary alkyd resin, together with high-strength pigments, and aromatic hydrocarbon thinners.

Application is by spray (at 30-40 p.s.i. pressure), dipping or flowing. Recommended uses are for all types of metal objects, where a quick-drying gloss finish is required, which needs to be handled or packed shortly after application, and where a coating of very good adhesion and flexibility is needed. Cox Bros. & Co. (Derby) Ltd.

EMD 882 for further information

Friction Material

A new friction material known as MW48 is now being marketed and consists of a solid woven asbestos material, impregnated with a synthetic resin. Excellent bolt-holding capacity is said to be assured by the inclusion, on the band side of the material (i.e., adjacent to the non-working face) of a fine brass wire reinforcement in both the warp and the weft yarns. MW48 is said to have a medium/high coefficient of friction and to possess rugged characteristics. It is also claimed to have a good frictional stability, resistance to fade, long life, "drum kindness" and not to smoke or burn.

The material is normally supplied undrilled in radiused blocks of standard size and thickness with a ground working surface. It can also be supplied drilled to customers' specifications or machine grooved for fitting by the Ferodo Ferolok or American Key-Lok methods of easy attachment and replacement. Ferodo Ltd.

EMD 883 for further information

Gasket Material

A new gasket material, Uniphase Cork, developed to eliminate seepage and leakage in applications where neither conventional cork composition nor cork and rubber have been completely satisfactory, has been recently announced. It is said to offer the maximum combination of impermeability and conformability with resilience and chemical inertness.

The main feature is its new continuous-phase synthetic elastomeric binder which encloses all the cork particles in a continuous matrix. As a result, it is said to present a solid barrier to the passage of fluids or gases. It is claimed to form a positive seal at unit loads as low as 100 p.s.i. where most conventional gaskets fail. The major reason for this is that the elastomeric binder actually conforms directly to the flange surface, completely filling surface imperfections caused by milling or abrading operations. Flange loads as high as 4,000 p.s.i. are said not to crush the material or cause it to extrude. It is also said to seal over a wider range of flange pressures than any other gasket material. Armstrong Cork Co. Ltd.

EMD 884 for further information

Anti-corrosion Compound

Lanshield Sakephen is basically a compound of some of the new synthetic polymers with special additives which are variable, to give material protection against specific conditions, such as rust, corrosion (by acids or by alkalis), abrasion, adhesion, exposure or scale formation.

It is claimed that under certain conditions it offers complete protection and in many cases makes it possible to dispense with the use of stainless, acid-resistant steels, non-ferrous metals and ceramic coverings.

In one form or another the coatings may be applied to wood, concrete or metal to prevent erosion and/or corrosion caused by various concentrations of acids or alkalis at temperatures up to 180 deg. C.

The coatings are said to have proved suitable for lining and covering apparatus, pipes and fittings of all kinds and sizes, conveyor systems, chimneys, etc., and their excellent release qualities are said to prevent bridging of powdered materials in silos and bunkers of concrete and steel. Wolseley Holdings Ltd.

EMD 885 for further information

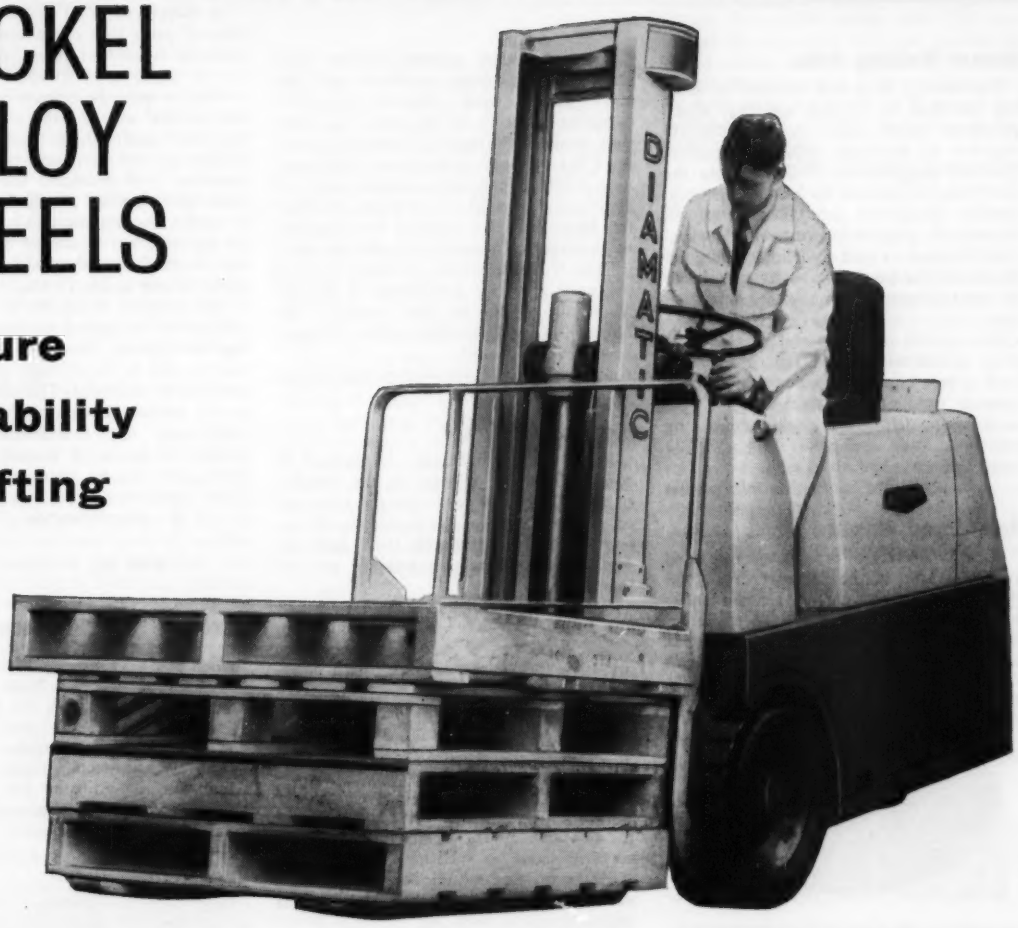
FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

READERS' ADVISORY SERVICE
We shall be pleased to help readers who have difficulty in tracing sources of supply of materials or components.

EMD 1016 for further information

NICKEL ALLOY STEELS

ensure reliability in lifting



The fork lift truck, of which this Diac model is an advanced design, epitomises the transition of labour from man to machine

This new unit, designed to achieve high operating speeds and quick servicing, incorporates various components made from eight nickel alloy steels, notably EN 33, the tried and proven 3 per cent nickel case-hardening steel long used for services where fatigue is a factor and wear resistance a requirement.

TYPICAL CORE MECHANICAL PROPERTIES OF

EN33

SIZE	HEAT TREATMENT	MAXIMUM STRESS t.s.i.	ELONGATION per cent	IZOD ft. lb.
1½" dia.	Oil quenched 860°C. Water quenched 770°C.	56·3	21·5	83
3" dia.	Oil quenched 860°C. Water quenched 760°C.	47·2	20	92

The benefits to be gained from the more highly alloyed case-hardening nickel steels, such as EN 33, EN 34, EN 36 and EN 39 include ease of heat-treatment, minimisation of processing distortion, and general reliability.

Send for "The Mechanical Properties of Nickel Alloy Steels" ▶

MOND NICKEL

THE MOND NICKEL COMPANY LIMITED · THAMES HOUSE · MILLBANK · LONDON SW1

YGA 21/2P

Bronze Welding Rods

Process-101 is a new method of joining cast-iron by process welding, which produces joints said to be infinitely superior to anything hitherto obtained. The old sluggishness of flow across the joint face is claimed to have been completely eliminated and a far greater degree of penetration into the parent metal is said to make peeling a thing of the past. The result is a weld claimed to be even stronger than the original cast-iron.

Process-104 is a new rod of the same alloy as Sifbronze Rod 101, but coated with a new type of flux coating for continuous welding. The flux itself is said to have a strong scavenging action on cast-iron and malleable iron. Suffolk Iron Foundry Ltd.

EMD 886 for further information

Reinforced Plastics

Resnit consists of a resin-impregnated knitted fabric, in the form of dry, semi-rigid sheets, which can be formed under heat and moderate pressure to make reinforced plastic components of complex shape. The outstanding advantages

claimed for Resnit are its practical suitability for mass production and its cheapness.

The two-way stretch characteristics said to be possessed by the material (when softened by heat) enable it to be used to form shapes which could only be made with difficulty, or in some cases not at all, in sheet metal.

The physical properties of the cured laminate can be modified over a substantial range by suitable choice of fibre, resin and other ingredients if required. Normally, density is in the region of 1·5, flexural strength 10 to 30,000 p.s.i. and modulus of elasticity 0·8 to 2 × 10^6 p.s.i. Leicester, Lovell & Co. Ltd.

EMD 887 for further information

Sintered Alloy

A sintered tool shank material said to possess remarkable characteristics that have gained it wide acceptance in precision machining in the U.S.A. is now available in the U.K.

Known as No-Chat, it is said to have an exceptional combination of physical properties, a modulus of elasticity of 40 × 10^6 p.s.i., a density of 16·96 gm/cc. (0·606 lb/cu in^3), a coefficient of linear expansion (100-200 deg. C.) of 5 × 10^{-6} per deg. C. together with an ultimate tensile strength of 112,000 p.s.i.

As it has a higher modulus of elasticity and hence greater rigidity than steel, these properties, combined with the high density and inherent vibration damping capacity of the material, mean that tools with shanks fabricated from No-Chat are said to produce better surface finishes than steel-shanked tools of identical size, with a minimum of chatter. Moreover, it is claimed that, because of the reduced tendency to chatter, tool-tip life is considerably increased even in the most rigorous conditions of service. It is said to be an ideal material for boring bars and grinding quills. Johnson Matthey & Co. Ltd.

EMD 888 for further information

Metal Conditioner

Pitan metal conditioner is claimed to combine at one application the benefits of metal pre-treatment with the first coat of a paint system. It is said to be so formulated that it bonds itself into the metal and becomes an integral part of that metal.

It is claimed to be effective on ferrous and non-ferrous metals and to have an adhesion figure of twice an orthodox, first-class primer (i.e., to form an adhesive film, not a cohesive film like paint).

When stove dried it is said to be practically impossible to remove it from any metal substrate. It follows from this that it will not crack, chip or flake.

It is claimed that it may be safely used on metals which have subsequently to be welded, for it leaves little ash and will cause no obstruction in the weld. It gives off no obnoxious fumes in the process of welding. Allweather Paints Ltd.

EMD 889 for further information

Polyester Photographic Film

Cronaflex is a new line of reproduction materials on Du Pont Cronar polyester photographic film base, and is now available in the U.K. in three types:

1. Direct positive film for exposure with high-density illumination in contact printers and direct process or blueprinting equipment. Both sides are matted to take pencil and ink. This film gives a same-size positive reproduction direct from the original drawing or other positive copy, and is said to be tough and to withstand temperatures up to 90 deg. C.

2. Contact film is designed to give positive intermediate for direct process reproduction or blueprinting where negative-positive steps are used, and is exposed in conventional vacuum frame, flat bed, continuous or contact printers.

3. Projection film is designed for use in process cameras and enlargers, but may be used in contact printing, with suitable adjustment of light intensity. It is said to be especially useful for reproduction or enlargements of drawings, maps or half-tones where durability and size-holding are important. Industrial Photo Equipment Ltd.

EMD 890 for further information

Improved Protective Paint

A metal coat that leaves a protective film of pure zinc when applied to steel surfaces is said to have been improved by the addition of an extra binder.

This is said to ensure a still harder surface and to make the paint more useful for applications such as anchor chains, gas cylinders and parts subject to abrasion and friction. The carrier has also been slightly changed. This is said to make no difference to the efficiency of the mix, but to enable the zinc to get into suspension more quickly, i.e., the paint is now easier to stir.

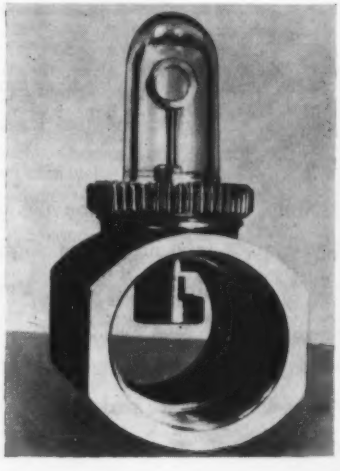
The product is known as Rust-Anode and it can be applied by brushing, spraying or dipping. The resulting protective coat is said to be strongly adherent, age-proof and rustproof. The coat is claimed to be touch-dry within 30 minutes and sufficiently dry for further treatment within 24 hours. It is said to be non-toxic and can be used with safety for food containers, fresh water tanks, etc. C. & P. Developments Co. (London) Ltd.

EMD 891 for further information

Variable Flow Indicators

The range of Arkon variable flow indicators has recently been extended to include sizes ¼ in., 1¼ in. and 2 in., in addition to ½ in., ¾ in. and 1 in.

The principle of cartridge construction has been applied in these instruments, which can be adjusted for high or low velocities of flow. The complete cartridge assembly is interchangeable between the



different sizes and the spindle impeller assembly, which is fitted in a cartridge housing, is said to be easily removed and reset for the required flow range.

A chromium-plated ring at the top of the spindle under a toughened glass dome stops spinning if the flow stops. Suggested applications are to indicate the flow of water, lubricating oil, cooling oil and other liquids. Walker, Crosweller & Co. Ltd.

EMD 892 for further information

Pressed Wing Nut

A new method of producing wing nuts in which a metal blank is pressed and then folded to form the nut is said to result in a reduction in cost compared to the orthodox forged type. The thread formed is included in the pressing, which is then folded forming a nut which is split into two halves but tied at the top by the fold. The halving of the thread allows the tension to be exerted on the bolt itself. When used in conjunction with a cupped component or washer the nut is self-locking. M. F. Robertshaw Ltd.

EMD 893 for further information

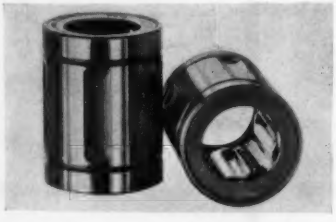
Air Bleed Valves

The introduction of a new series of air bleed valves has recently been announced. Models are available for welding direct to pipes or cylinders and, also, with threaded connector ends of various sizes for attachment by screwing into convenient tappings in hydraulic systems. The valves are designed for bleeding off air from hydraulic systems and bleeding is carried out by loosening a hexagon head screw and allowing a ball to unseat, releasing air trapped in the system. The sealing balls are of 12 per cent chrome, 1 per cent carbon, martensitic hardened stainless, for combined properties of corrosion resistance and hardness. Hydraulic Components Co.

EMD 894 for further information

Ball Bushings

A range of ball bushings for linear motion is announced. Three or more circuits of balls are provided within the bearing, each of which has the balls in one of its sides in bearing contact between the inner surface of the ball bushing sleeve and the shaft. Linear motion causes recirculation of the balls, a retainer within the sleeve providing the necessary guidance. Working bore sizes range between ¼ in. and 3 in. outside



diameter, outside diameters in this range varying between ½ in. and 4¼ in. Ransome & Marles Ltd.

EMD 895 for further information

Flameproof Motor

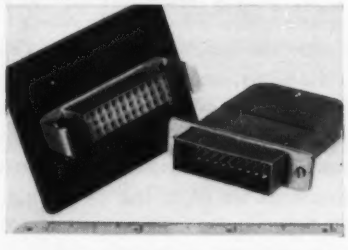
This motor is specially designed for continuous operation in the presence of inflammable gases or dusts, and is said to be particularly suitable for use in the petroleum, chemical and coalmining industries. The flameproof construction is to B.S. 229: 1957 for groups 1, 2 and 3 gases. The rating and performance is to B.S. 2613: 1957 for all groups, and to B.S. 741: 1937 for group one only.

Alternative methods of electrical connections are incorporated in the design of this motor as follows: (a) a sealing chamber with double or single gland and clamp for an armoured cable (groups 1, 2 and 3 only); (b) a sealing chamber with a single or double screwed gland for seamless conduit (groups 2 and 3 only); (c) a single plug and socket coupling (groups 1 and 2 only); or a screwed gland for mineral insulated copper-covered cables (groups 2 and 3 only).

Special features of this motor include: casing joints are metal to metal; cartridge-bearing housings are fitted as standard; when servicing, tho rotor can be completely removed without exposing bearings to dust or other harmful matter; end-shield cavities are isolated from each other, avoiding an explosive pressure build-up. A non-fan-cooled version of the motor is available. Brook Motors Ltd.

EMD 896 for further information

Multi-point Connector



A component said to be the smallest of its kind on the market has been developed to simplify mass connections in confined spaces. Only 1 in. in length, the connectors can be mounted in units of ten up to sixty, either end-to-end or side-by-side. At present, the insulating material is of nylon, but p.t.f.e. will be available shortly to allow working temperatures between −50 deg. C. and 200 deg. C. Siemens Edison Swan Ltd.

EMD 897 for further information

Steam Control Stop Valve

A new control stop valve for use in steam lines is being introduced. Known as the Bi-seat, the precision-made unit is said to be of a unique, patented design which, it is claimed, affords an extremely high degree of control and double protection of the working parts. It is designed for controlling a flow of steam at working pressures of up to 300 p.s.i. and temperatures as high as 200 deg. C., particularly where frequent use is expected.

On initial opening, the main valve is raised approximately $\frac{1}{16}$ in. clear of its flat seat, but the orifice remains sealed by a special spring-loaded parabolic plug. As the unit is opened more fully, the plug is gradually withdrawn from the orifice to provide a streamlined annulus for the passage of steam. This design is said to make it virtually impossible for foreign matter to be trapped on the main valve seat, and the fine degree of control to allow steam to be admitted slowly to a cold system with full protection for the valve and seat against the direct cutting action of the high velocity steam, thus preventing wire drawing. All working parts are made of K monel and stainless steel. Sir W. H. Bailey & Co. Ltd.

EMD 898 for further information

New Motors

Three new motor ranges are announced, the first range being totally-enclosed motors in NEMA "66" frame dimensions intended to bridge the gap between the f.h.p. and the industrial range of motors. The range is ½-1½ h.p. single-phase and ¾-2 h.p. three-phase. It is claimed that these motors have been designed with extra mechanical strength and toughness for industrial applications.

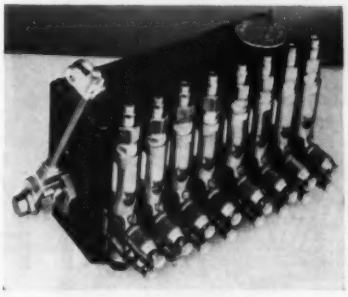
The second range of motors is believed to be of interest to machine tool and hoist manufacturers; they incorporate an electro-magnetic brake designed on the disc principle and actuated by a.c. supply. The motors can be supplied drip-proof or totally enclosed.

The third range covers close-coupled pump motors (½-40 h.p.) having NEMA C-type face bracket and a specially designed shaft extension on to which the pump impeller can be directly mounted. Drip-proof, totally-enclosed or flameproof/explosion-proof motors can be supplied. Newman Industries Ltd.

EMD 899 for further information

Mechanical Lubricator

A new mechanical lubricator, known as the DP 60, is available in a range of sizes to give from 1-32 feeds. It is a precision instrument which feeds oil at a

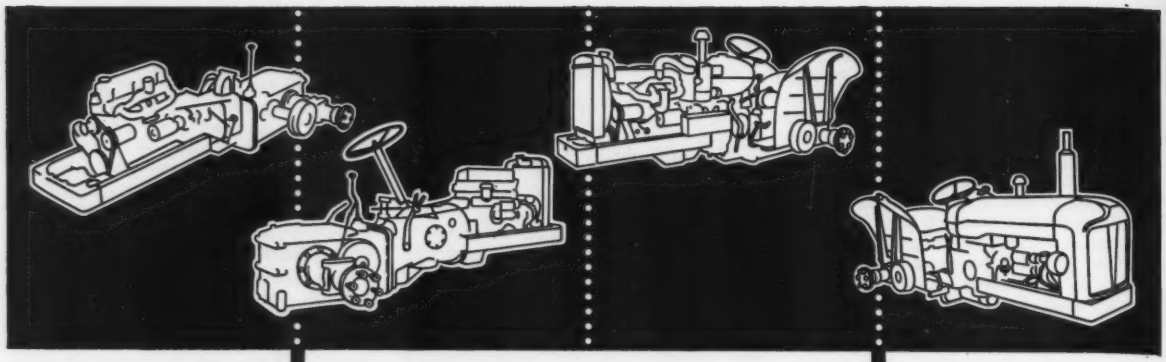


predetermined rate and in a predetermined quantity to the frictional surfaces of a machine.

The lubricator is normally actuated by the machine being lubricated and the oil supply, therefore, automatically commences and ceases with the movement of the machine. The human element is thus kept to a minimum and it is claimed that efficient lubrication is combined with economy in oil consumption.

The sight feed glass is a perspex tube and metal shroud said to be capable of withstanding 2,000 p.s.i. The oil reservoir is of welded steel construction which, in an eight-feed lubricator, is said to give a weight saving of as much as 29 lb. over the usual cast-iron type of reservoir. C. C. Wakefield & Co. Ltd.

EMD 900 for further information



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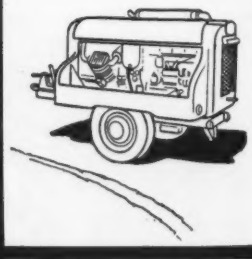

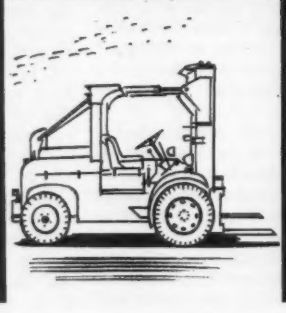

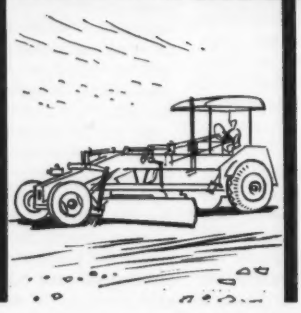

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Moulded Current Transformers

The CD5 is a wound-type current transformer with the primary and secondary coils arranged concentrically on one limb of the core. The windings are embodied in solid insulation consisting of an epoxy resin with hardener, silica sand and other special ingredients. The mixture is prepared and poured under vacuum, and the castings are hardened by curing in an oven. The casting is said to possess great mechanical strength, good thermal conductivity, high temperature resistance, low dielectric loss, high resistance to cracking and low moisture absorption.

Special care of moulding tools and a detailed study of release techniques have enabled the manufacturers to produce a transformer with high-gloss surface finish. This, combined with its smooth contours, is said to give the CD5 the greatest possible resistance to dust accumulation. Also, the use of solid filled resin for insulation is said to enable it to withstand the harmful effects of a corrosive atmosphere. Crompton Parkinson Ltd.

EMD 901 for further information

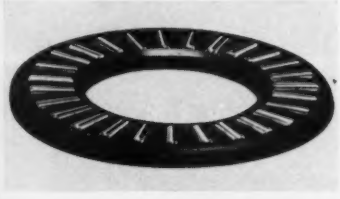
Nylon Screws

Screws moulded in A.100 nylon and which are said to be inherently self-locking are available in B.A. sizes and lengths from $\frac{3}{16}$ in. to 1 in. These screws are resistant to a wide range of chemicals and do not soften below 150 deg. C. Additional advantages claimed are high dielectric strength for electrical applications and light weight. Guest Keen & Nettlefolds (Midlands) Ltd.

EMD 902 for further information

Needle Thrust Bearing

Important advantages in space-saving design and reduced bearing costs are said to be obtained by the new Nadella needle thrust bearing now available in the U.K. This type of bearing consists of a retainer of hardened steel with



pockets grouped like the spokes of a wheel to hold the needle rollers and a raceway of hardened bearing steel.

The main advantages claimed for the new bearing are (1) greatly reduced axial space requirement of only 0·11 in., (2) capacity to cope with substantial thrust loads, (3) low friction coefficient permitting high speeds without overheating, (4) robust construction and simple lubrication, and (5) low unit cost. Insley Industrial Supply Co. Ltd.

EMD 903 for further information

Air Pressure Regulator

By a simple screw adjustment, inlet pressures of up to 250 p.s.i. can be regulated down to a range of 5-125 p.s.i. to suit the requirements of a tool or machine with a new type of air pressure regulator. The manufacturers claim a higher capacity and faster response with less pressure drop, as loads are increased, than any other regulator available today. The regulator, which is available in two models, one with and one without a dial gauge, is made from corrosion-resisting materials. Servicing of the unit can be carried out without disconnection from the air line. A. Schrader's Son.

EMD 904 for further information

Time Delay Unit

A new electric motor control gear intended for industrial or other timing applications incorporates an electronic time-delay unit. It is said to be suitable for use with start-to-run motor switching on hand-operated starters, slip ring automatic starters, motor braking periods, sequence starting and stopping, and process control timing and cycling. A life well in excess of ten million operations is claimed.

A notable feature is said to be the infinitely-variable time-delay setting. This is obtained by using a coarse control switch in conjunction with a variable rotary sliding resistance to give fine adjustment.

On a model 3A timer on 415 volts, which has a maximum time delay of two minutes, there is a coarse switch with twelve positions. The first position has almost 0 sec. delay, the second position has 10 sec. delay, the third 20 sec. delay, etc. The fine setting control is used for times falling between the values rising at 10-sec. intervals on the coarse setting switch. Brook Motors Ltd.

EMD 905 for further information

Forged Flanges

For applications where cast flanges do not give adequate strength, a range of forged flanges is now available in alloy steels. The range includes welding-neck, slip-on, lap-joint, threaded, blind, socket-type, reducing, orifice or specials. Sizes range from $\frac{1}{2}$ in. nominal bore to 12 in., and it is intended shortly to produce flanges in all alloys, including Superston, Hastalloy, Zircalloy and other specialised alloys. H. & E. Lintott Ltd.

EMD 906 for further information

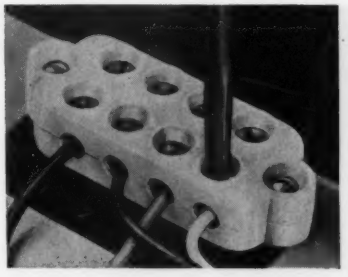
Electromagnetic Counters

The Hengstler electromagnetic counters, types F43 and F43M2, are now available in this country. Said to be capable of counting at speeds up to 2,400 impulses per minute and having an extremely long life expectancy, the units are basically similar in design, both providing six-digit indication. The F43 incorporates manual reset and the F43M2 has both manual and electrical reset. Both types are available in high-speed or low-speed versions and at a number of preferred operating voltages. Rectifier units for operating at certain preferred ratings will also be available in the near future. Lancashire Dynamo Products Ltd.

EMD 907 for further information

Terminal Block Connectors

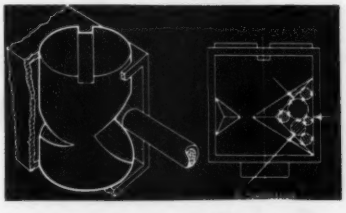
What is said to be a new principle in electrical connections is claimed to eliminate screws, lugs, soldered joints, spring-loaded contracts and other methods.



Called the Camblock, it provides wedging action on the cable by a rotary tapered V-cam.

A quarter-turn of the cam locks or unlocks each terminal. Toggle-like action, with constant pressure at centre line of cam axis, is said to assure positive locking (the harder the wire is pulled, the tighter the cam grips it).

Compression grips the wire all round when the cam is locked. The sloping



sides of the wedges and busbar wall bind the conductor strands from three directions in a tight vice-like grip, making every strand carry current for 100 per cent conductivity. International Engineering Concessionaires Ltd.

EMD 908 for further information

Differential Pressure Control

A new differential pressure controller has been designed for use in high-velocity dual-duct air-conditioning systems. It is designed to ensure a constant volume of air distribution through each mixing box in the system, regardless of the number of boxes, length of duct or variations in inlet pressure of the hot and cold air supplies.

It is claimed that there are no variations in the sound level of the system as the output volume and velocity are maintained constant at all times and under all conditions. The controller operates from the existing air supply system and is said to be economic in operation, no additional power being required. Drayton Regulator & Instrument Co. Ltd.

EMD 909 for further information

EMD 1021 for further information

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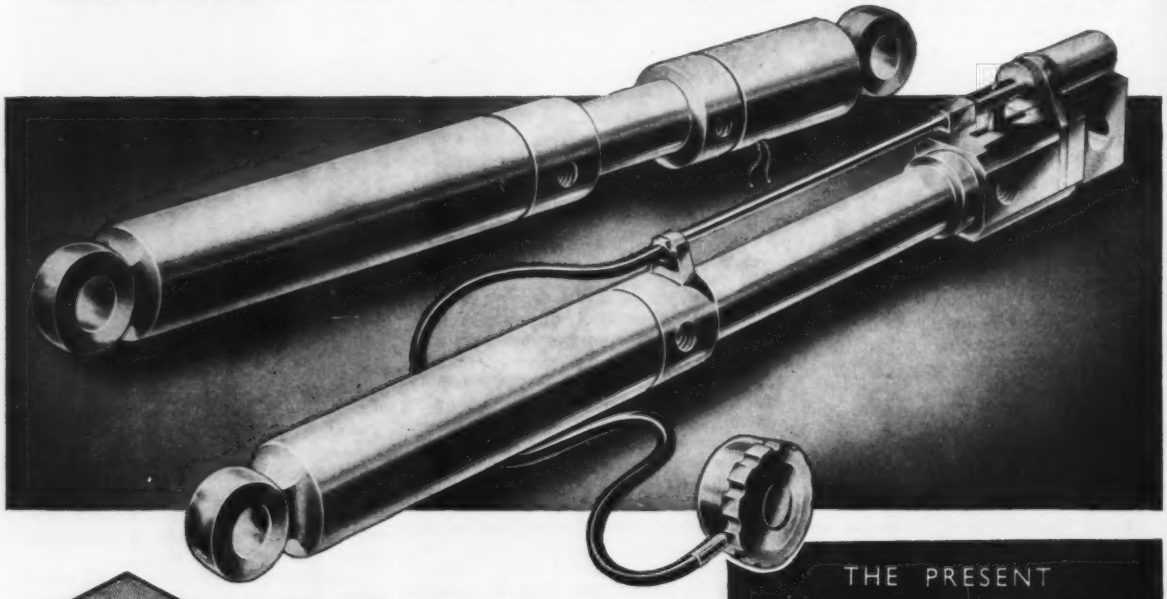

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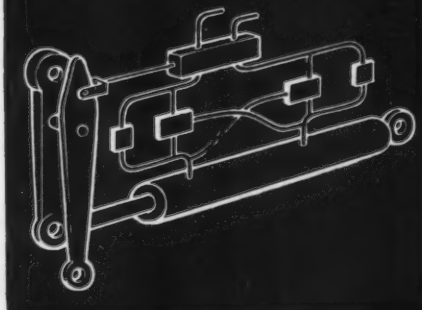

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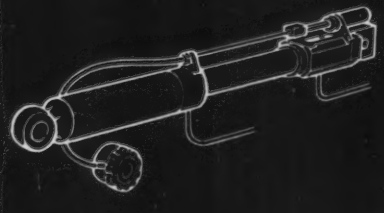

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News of Industry

I.C.I. Ltd. is to introduce a new polypropylene material under the trade name of Propathene. It will be made here under Montecatini U.K. patents at a new plant being built in Yorkshire, but production is already under way at a pilot plant. The material is particularly suitable for moulding uses because of its higher rigidity and temperature resistance. It is also expected to find extensive use in film form and as a general extrusion material.

Three new companies have been formed by the **Blackburn Group,** to be known as Blackburn Aircraft Ltd., Blackburn Engines Ltd. and Blackburn Electronics Ltd., to take over, respectively, the aircraft, engine and commercial electronics divisions. The parent company (Blackburn & General Aircraft Ltd.) will in future operate merely as a holding company.

The American Society of Mechanical Engineers has announced that members of organisations represented on the Engineers' Joint Council or the Engineers' Council for Professional Development are now entitled to attend all A.S.M.E. general meetings and conferences for the same fees as A.S.M.E. members. This ruling thus includes members of the British **Institution of Mechanical Engineers.**

Johnson Matthey & Co. have acquired an interest in the Italian precious metal refining and manufacturing company of Metalli Preziosi S.p.a. of Milan. The two companies have collaborated for some years, and the new association provides for closer technical as well as commercial links.

Two new short films have been produced by European associates of **Mobil Oil Co.** One, entitled "Lubricants with Care", was made in France, and the other, "Compressor Lubrication", was made in Italy; both have won awards at technical film festivals. English versions are available in the U.K.

Mr. L. Rotherham, member for research of the Central Electricity Generating Board, has been co-opted to the council of the British Welding Research Association.

Development of new engines is to be intensified by the Perkins group, according to an announcement of the formation of a new subsidiary to handle sales and servicing, to be known as **Perkins Engines Ltd.**

A large new bay has been completed at the Warrington works of **William Robertson Ltd.** New equipment has enabled the "throughout" time, from black bar to the finished product, to be reduced to less than one hour, said to be the fastest production rate in Europe for precision bright steel bars.

Mr. D. A. Senior has been appointed to the new post of scientific attaché to the British Embassy in Moscow. He will advise the British Ambassador on scientific matters and report on Soviet scientific and technical development in the civil field. Mr. Senior, who is 35, will have the rank of senior principal scientific officer and will be on the staff of the D.S.I.R. He has been at the Admiralty Research Station at Teddington since 1950, concerned mainly with problems of instrumentation and combustion.

The Ergonomics Research Society recently held a conference at Oxford of workers in the field of activity in the U.K., Germany, Holland, the U.S.A., France and Sweden. The Society, now in its tenth year, was founded to bring together scientists engaged in different industries, but with a common interest in problems of human efficiency at work.

An inflatable lightweight building was recently introduced by **Gourock Ropework Co. Ltd.,** in collaboration with I.C.I., British Geon and British Nylon Spinners. Made of p.v.c.-coated nylon or Terylene fabric, the shape of the structure is maintained solely by a differential air pressure of approximately ½ in. water gauge supplied by two blowers, each of which is capable of delivering some 3,500 cu. ft. of air per minute. Once inflated, one fan easily compensates for leakage. If failure of air supply occurs, the fabric will take ten minutes to collapse to head height. The structure offers good light diffusion and, when folded, compactness (a 54,000 cu. ft. model folding to 6 × 6 × 3 ft.).

Metallic Surfaces Research Laboratories Ltd., who offer under licence the Arkrom chromium diffusion process, are now making available a small sample-treatment unit to give prospective licensees an opportunity to assess the merits of the process. The unit comprises a vertical electric furnace, with maximum rating of 1·5 kW. operating on 200/250 volts, with an energy regulator, a processing retort of effective treatment dimensions 6 × 1½ in.

The functions of the **Professional Engineers' Appointments Bureau** have now been taken over by the Engineers Guild, following discussions between the two bodies. The bureau was formed in 1945 with the support of industry and the engineering institutions, and it has established itself as a principal channel through which professional engineering appointments are filled. A new division has been created within the guild to continue this work as before for corporate members, graduates and students of the Institutions of Mechanical, of Electrical, of Chemical and of Civil Engineers.

Dunlop Advisory Service Ltd. recently exhibited a model of the 79-acre factory planned by them for erection at Dneipropetrovsk in the U.S.S.R. for the production of vehicle tyres of all sizes. This factory, already in construction, will be capable of turning out two million tyres a year of all sizes when in full production in the latter part of 1960. The factory is being equipped by Rustyfa Ltd., a consortium of British companies; the total value of this project is estimated at £15 million, with further possible additions in the future. It is probably one of the most highly automated factories built, each process being sequenced and controlled to give optimum properties to the materials used and to ensure maximum output.

Mr. Fedor Oleynik, leader of the U.S.S.R. delegation studying plastics developments in Europe, discusses a point with Dr. R. Reed, head of research at Whiffen & Sons Ltd., which was one of the British companies visited by the delegation.

Dunlop Rubber Co. is now marketing conversion kits to enable conventionally sprung vehicles to be fitted with pneumatic suspension systems.

The **Mechanical Engineering Research Laboratory** at East Kildbride is in future to be known as the **National Engineering Laboratory.** Announcing this, the D.S.I.R. says the change is to emphasise the national character of the laboratory. There will be no major change in its scope, but it has been decided to set up a steering committee which will be responsible for planning the laboratory's activities and the selection of future research projects.

Metropolitan-Vickers Electrical Co. recently held a one-week Easter vacation course for boys and girls from public and grammar schools throughout the country. As guests of the company, they spent half of each day under instruction in the apprentice training school, and the other half visiting manufacturing departments and design laboratories.

Two new laboratory blocks are being built at the research laboratories of **Mullard Ltd.** near Redhill, Surrey. Part of these will be devoted to improving facilities for valve, semi-conductor and materials research.

EMD 1022 for further information

Spotlight on...

ROUNDS Sizes: 1/16″ to 8″ diameter

SQUARES Sizes: 1/4″ to 1″ across flats

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RECTANGLES 3/16″ to 1-1/2″ thick 1/2″ to 10″ wide in 1/4″ increments

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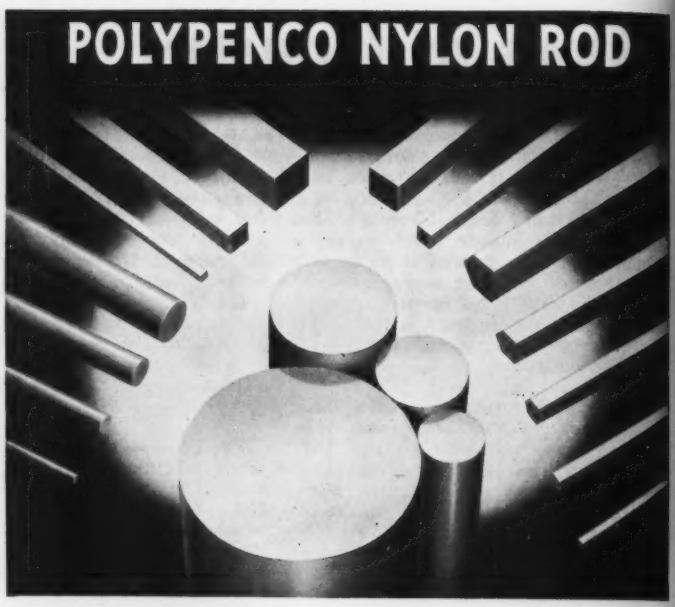
- GOOD ELECTRICAL INSULATOR FOR LOW FREQUENCY, HIGH VOLTAGE APPLICATIONS



★ Nylon is the generic term for the polyamide family of the following grades: Type 66, Type 610, Type 6, Type 11, MoS_2 and graphite filled Type 66. Each grade has specific properties for different operating conditions.
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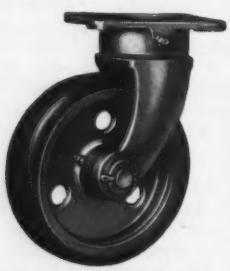

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